

CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 24

San Francisco, April, 1938

Number 2



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DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND GAME
San Francisco, California

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CALIFORNIA FISH AND GAME is a publication devoted to the conservation of wild life. It is published quarterly by the California Division of Fish and Game. All material for publication should be sent to Richard S. Croker, editor, California State Fisheries Laboratory, Terminal Island, California.

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TROUT FISHING IN SOUTHERN CALIFORNIA STREAMS—INSTRUCTIONS FOR THE BEGINNER¹

By DONALD H. FRY, JR.
*California State Fisheries Laboratory
Division of Fish and Game*

INTRODUCTION

There are many people in southern California who would like to go trout fishing but who know absolutely nothing about the subject. Many such show up at the stream side with surf tackle, black bass outfits, or other equipment totally unsuited to the work at hand. The only thing they ever catch is a case of poison oak. Others throw themselves on the mercy of a tackle salesman and reach the stream with gear which is suited to the work at hand but with absolutely no ideas on how to use it. Such people often fish industriously for hours without getting a nibble or seeing a fish, and finally convince themselves that there are no trout in the stream. Three of the most pathetically bewildered beings I have ever seen were in that frame of mind when a big kid strolled around the bend and went past them on the far bank of the creek, pausing every few steps to extract another trout. He caught eight almost under their noses and strolled on, around the next bend. Such experiences are apt to be heartbreaking and make the beginner give up in despair. The affair savors of black magic; the expert produces trout from an empty stream like a conjuror taking rabbits out of a hat, and the beginner has no trace of an idea how he should act in order to do likewise. What he should do is to make friends with some really good trout fisherman who will take him out, show him what to do, what not to do, and explain the why of each. A rank beginner whose every move is being coached by a real expert will often get more and bigger fish out of a stream than a fairly good fisherman who is on his own. What is even more important, a beginner under proper guidance will soon learn enough to give him a good start so that he can keep on learning—and learning fast—when he is alone.

Many beginners have no expert friends, and this article is an attempt to do for them with words and pictures what a teacher would do for them with words, demonstration and pointing.

This article will confine itself primarily to bait fishing because in southern California a beginner will do far better to confine **himself** to bait until he has at least learned the rudiments. There are a few times, particularly during extreme low water, when flies may produce better results, but at such times flies must be handled very expertly. The beginner who starts by using bait will learn a lot about streams and trout and will probably pick up some knowledge of fly fishing by watching others. Then he can graduate into fly fishing if he desires.

¹ Submitted for publication, February, 1938. All photographs by the author. The author wishes to express his appreciation to Mr. Lawrence Spooner of the New York Hardware Trading Company, Inc., Los Angeles, who read the manuscript and offered valuable suggestions.

Many experts will have methods which they prefer to the ones given here. The methods given do not pretend to be the ultimate, but they work excellently in southern California and will do reasonably good work in similar streams almost anywhere.

Obviously, in a paper of this size, it is impossible to do much more than cover the rudiments for a fairly limited set of conditions. Any one who wishes to make a real study of trout fishing can find many good books on the subject. One excellent book which goes into nearly all phases and yet is easy reading for a beginner is "Just Fishing," by Ray Bergman (Penn Publishing Co., Philadelphia, 1932).

TROUT TACKLE

The tackle required for fishing a trout stream is essentially very different from that used for trolling, bait casting or ocean fishing. The beginner who uses a surf rod, for example, is so handicapping himself that he is doomed to certain disappointment. He would be far better off using a flexible piece of willow.

When a beginner buys his outfit he should by all means go to a store which has a really large assortment of tackle. Such places have salesmen who know tackle from A to Z and many of whom are really expert in its use. Buy your tackle some time when there is no crowd in the store (**not** the day before the season opens). Ask for a salesman who knows trout fishing and tell him you are a beginner. Most real tackle salesman are the sort who will regard that as a compliment and will gladly spend an hour or so giving excellent help and advice on tackle, how to use it, where to go, and how to get there. Occasionally you will get a salesman whose only interest (if he has **any** interest) is in selling you something. When this happens go to another store.

The cost of trout tackle can be fitted to almost any purse. You can spend over \$60 for the rod alone, or you can get an entire outfit for \$5. An excellent outfit for a beginner can be purchased for \$20-\$25.

License

Properly speaking, this isn't fishing tackle but don't forget to buy one if you are over eighteen years of age. The cost is \$2 for citizens who are residents of California, \$3 for nonresident citizens and \$5 for aliens. The license entitles you to fish in fresh or salt water any place in the State that has not been specifically closed; it is good until December 31 of whatever year purchased.

Rod

The rod is the most important piece of equipment and is the one on which the least skimping should be done.

The only really suitable type of rod for trout fishing in small streams is a single-handed fly rod. Such a rod is long, slender, and has the reel mounted below the handle.

The best rod material is split bamboo. In the standard type of construction, six triangular strips of bamboo are glued together with the enamel or skin side out and are thus made into a rod of hexagonal cross section.

Besides split bamboo there are rods made of steel and various solid woods. For trout fishing these materials are decidedly second choice except for one special set of circumstances. When fishing a very brushy stream, a telescoping steel rod is nice. It is heavy and its action is terrible but you can shorten it down to a three-foot length, bull your way through a thicket and lengthen it out again to fish the next pool. Incidentally, such rods are very cheap.

The cost of a fly rod may be anything from \$2 to \$60 or even more, and the great worry of most of us is how much to pay. A really high class instrument will cost \$30 or more, will last a life time, and will be much nicer to use than a cheaper rod. However, a beginner will not be able to pick one he would like to use the rest of his life, and until he gets used to carrying a rod over rough country, there is always a chance he may break it. For a beginner to whom \$30 is a lot of money, the logical thing would be to get a cheaper rod and learn how with it. There are good rods to be had for as little as \$6 or \$8, but there is also a lot of junk for sale in that price range, so be careful when you make your selection.

A good rod to use for stream fishing is one which is from eight to nine feet long and which has a fairly stiff (dry fly) action. Such a rod will probably weigh from four to seven ounces. Longer rods are not so satisfactory for small or brushy streams, and those which are shorter than eight feet are usually either stubby affairs or very light fairy wands. The stubby type is fairly satisfactory for small streams, but not for much else, and the very light rods (1 to 3½ ounces) are suitable only for use by an expert and only for fly casting.

The rod should be husky enough to lift ashore fish up to eight or nine inches long. Theoretically no fly rod should be subjected to this strain, but most southern California streams are of a waterfall and pot-hole type, and if you are standing near the head of a pool when you hook a fish you will often scare everything else in the pool while doing some wild scrambling to get to a place where you can beach or net your catch. So get a rod heavy enough to stand lifting them out, because you will be doing it anyhow.

Rods are made in various degrees of stiffness and that stiffness is by no means entirely dependent on weight. Get one which has the proper "action" and don't worry too much about how much it weighs. Rods in the eight- to nine-foot class can be purchased with wet fly or dry fly action and some nine-foot ones are designed for bass flies. The typical wet fly rod is too limber for dry fly, bait or spinner use, whereas bass fly rods are too stiff for best use on small streams. The dry fly rod is the best all around instrument for trout fishing and a well made nine-footer will do good work on bass or steelhead as well.

When you select your rod ask to see and feel the action of some of the really fine ones—they will give you an idea of what to look for in whatever price range you decide to patronize. To select a rod, put it together and point it horizontally. Does it bend slightly in an even graceful curve? If not, don't get it regardless of price. Revolve it slowly. Does it keep the same curve or does it bend more in some positions? The guides may stiffen one side **very** slightly, but if there is any other unevenness, don't buy it. Tie a light weight (an ounce or so) to the tip so as to bend it more and repeat the above tests. Point the rod

where there is no danger of hitting anything with it and snap your wrist a trifle to bend the rod. Does it ooze back into position or does it come back with a snap you can feel? A rod which oozes back is too flexible for general use. Stiffness, or backbone, is hard for a beginner to gauge properly—you will have to rely on another person to some extent. Does the rod feel right? (You can tell this better if you put a reel on it.) Look at the ferrules (joints). Do they slide into each other firmly but smoothly? Do they come out with a decided “plop”? Are they well fitted to the wood? The better rods have ferrules which are split at the ends and these splits are lashed down with silk windings. This lets the end of the ferrule spring slightly with the wood and greatly reduces the chances of a rod breaking at the joint. You will probably get a rod which is in three sections. Be sure there is a spare tip. The reel seat may be of wood or metal and the clamping band may screw or slide into place. Try a reel on it and see if it holds the reel firmly. Line guides should be large, so the line will pass through them easily. The first guide (nearest the handle) should be a ring of steel or agate. The rest should be light steel. If the tip guide should be of agate, be sure it is well guarded with metal—an exposed agate is sure to get chipped, and a chipped agate will ruin a line in short order.

Line

When using a fly rod on a lake or large stream it is important to have a line which properly matches the rod. On small streams you can get by with a mismatched outfit—but why try to?

When casting any distance with fly, bait or small spinner, it is the weight of the line which carries the leader and lure. The line must be heavy enough to do this, and must be heavy enough to bring out the action of the rod. When using a well-balanced outfit, the rod throws the line much as a bow shoots an arrow. At the start of the forward cast, the inertia of the line bends the rod backward, then the wood snaps straight and flips the line forward with far more speed than you could possibly get with wrist action alone. Too light a line will not bring out this action and one that is too heavy is simply too much of a load for the rod.

To pick a line of exactly the right weight is a job for an expert, but a beginner can come fairly close by using the following table:

Rod	Level Lines (Untapered)	Tapered Lines
8-8½ feet flexible (wet fly)-----	G or F	H F H
8-8½ feet stiff (dry fly)-----	F	H E H
9-9½ feet flexible (wet fly)-----		
9-9½ feet stiff (dry fly)-----	E	H D H
9-10 feet very stiff (bass and steelhead rods)-----	D	H C H

Most manufacturers use the letter system to denote fly line sizes, and although the sizes of various manufacturers do not always correspond, they are usually close enough to the general average. Tapered lines are small at both ends and large in the middle. An HEH line, for example, is size H at each end and size E in the center.

The amount of line you will need is very little. Fly lines are usually sold in coils of 25 yards, 30 yards, or 100 feet. One coil of 25 yards is all you will need.

Fly lines are made in three finishes: oiled silk, hard enamel and soft enamel. The soft finish lines are often known as "oil impregnated lines" but must not be confused with oiled silk.

Oiled silk has nothing to recommend it except price. You can get one for 25 cents, but don't.

Hard enameled lines are made of silk with a hard smooth enamel on the surface. Sooner or later this enamel begins to crack and peel off, but a good line may last several seasons. The price varies with size as well as quality. The lightest you should ever try to cast with (size G) will probably cost from \$0.50 to \$1.25 for a 25-yard coil. Heavier lines cost a bit more—in size D the price range is roughly from \$1 to \$2.

Soft enameled (oil impregnated) lines are the most expensive, but if you are lucky you may get one which will last a life time. They are made with a soft smooth finish which penetrates clear through the silk, so there is nothing to crack or peel, but there is one disadvantage which the hard finish does not have. Some soft finished lines will get sticky in spite of anything you can do and such a line is an abomination. Never buy one which shows the faintest trace of this ailment—it will always get worse, never better. A soft finished level line of the highest quality will cost from \$1.75 to \$3.50.

Recently some manufacturers have made cheap soft finished lines to sell at about the price of hard enameled ones. The finish is soft, but as you can easily tell by a close examination it is more of a surface finish than that found on the highest grade products. When compared with hard finished lines, these new products show less tendency to crack and peel, but some of them turn sticky. On the whole they seem to be a slight improvement on the hard enameled lines.

Tapered lines have some advantages over level ones, but for a beginner who intends to do most of his fishing in small streams they hardly seem worth the added cost. The ends of tapered lines are fine, so they can be cast more delicately and the extra weight in the center makes it possible to do extremely long distance casting with them. With moderately light rods, such as are used in small streams, the line which matches the rod is not heavy enough so that there is any real need for a tapered end, and there is almost never any occasion to do any long range work.

If you do decide to get a tapered line get a good one, with the best type of soft enameled finish. It will cost from \$5 to \$10 or even more. **Don't** get a cut-rate product. You would be far better off with a good level line costing half as much.

To test a line before buying it: loop the end and pinch the loop. Don't buy it if the enamel cracks or discolors or the line shows a tendency to bend more readily in that place. Take a few turns off the coil of line and throw the length out straight onto the counter. A high priced line should lie flat in whatever position it hits and not try to re-form the loops. Less expensive lines should not be expected to lie perfectly flat and straight, but don't buy one which acts like a watch spring.

Reel

Trout reels are used primarily to hold line and to balance the rod. They do not need to be expensive, and there are many nice ones on the market for as little as \$2. You can get a beauty for \$3.50 to \$5, and even for the heaviest steelhead and bass fishing there is absolutely no need to spend over \$8. The reel should be a single action one, and the handle knob should be on the side of the line drum itself. The line is less apt to catch on a reel of this design than on any other. Narrow reels of large diameter are the easiest to use. With this shape, the operator can reel in rapidly and he does not have to pay any great attention to make sure the line spools evenly on the drum. Be sure the reel is large enough to take the size of line you are planning to put on it and have room to spare. A tightly filled reel is an abomination.

To make casting easier and thus save wear and tear on the wrist it is important to have a reel which balances the rod. To do this, it should weigh in the neighborhood of $1\frac{1}{2}$ times as much as the rod. When put together, the outfit should balance at the upper end of the cork grip or within six inches above that. Hang your coil of line on the reel handle while checking the balance; then remove the coil and see if the outfit **feels** right. Some experts claim the above method is false and deceiving—but the beginner need not worry about being too badly deceived by it.

It is easy to get a trout reel which will balance a $7\frac{1}{2}$ - $8\frac{1}{2}$ foot rod, but most reels (especially the lower priced ones) are too light for a longer rod. This difficulty can usually be overcome by the judicious use of a little lead. If the reel arbor (hub) is small and solid you can wind a narrow strip of sheet lead around it. If it is large and hollow, fill it with shot and use a piece of adhesive tape to keep the shot in place.

There are two ways of mounting the reel on a fly rod. The more common one requires that the reel be mounted right handed for use by a right handed person. The reel is placed so that the handle is on the **right** side when the reel is hanging under the rod. When the outfit is assembled this way the rod is held in the right hand for casting and is switched to the left hand when reeling in.

The other system seems far more satisfactory to the writer. It requires that the reel be mounted left handed for a right handed person. The handle is on the left, the rod is always held in the right hand and the reel is operated by the left hand. There is no switching of the rod from one hand to the other just as the action starts.

The clicks on most cheap reels are so designed that they offer about equal resistance to reeling in or paying out. Such reels can be mounted either right or left handed. On some medium priced and expensive instruments, the click lets the line come in much more easily than it goes out. On some models this can be easily reversed for left handed mounting. You may like a reel on which the click can not be reversed, or one which has a line guide. If so, be sure you know whether you want a left or a right handed reel.

A trout reel is mounted below the rod handle where it can't readily be thumbed and thus kept from over-running. For this reason most such reels are made with a click which is on at all times. If you can turn your click off don't do so while fishing—it is courting disaster.

Enameled line should not be wound in a very tight coil, hence if the reel has a very small arbor it should be partly filled with some old line. Cotton or linen will do. **When you wind the line off the coil turn that coil as though it were a spool mounted on an axle**—this method takes longer, but it doesn't twist the line.

If you plan to hold the rod in your right hand and reel in with your left put the line on by turning the reel counter clockwise.

Leaders

A leader, as used in trout fishing, is a length of some inconspicuous substance which is placed between the line and the hook in the fond hope that the trout will not notice it.

Most beginners on southern California trout streams use leaders which are too short and far too heavy. All too often a 3-foot leader of 10-15 pounds breaking strain is used where a 6-foot one of less than two pounds test would be necessary to get results.

Trout leaders are made of silkworm gut or of imitation gut. Each has its advantages and disadvantages.

Imitation gut can be obtained in any desired length. It is very cheap, and can often be purchased in 5- to 40-yard coils for as little as a cent per yard. It is a little stronger than the natural gut. When wet, it is too sloppy to cast nicely. In quality, it varies from excellent to worthless and it is hard to know which you are getting. Try soaking a piece in water overnight and test it the next morning. If it is still strong you won't need to worry. Another disadvantage of imitation gut is that when wet it is so slippery that special knots have to be used in tying it. **Remember that.** The size of imitation gut is usually given as so many pounds breaking strain—a very convenient method. In appearance, imitation gut is translucent and silky.

Natural gut has a clear glassy luster. If you examine it closely you can be sure of getting good quality. The gut itself comes only in short lengths (up to 18 inches). The tackle maker knots these sections together to make a leader. A 6-foot, high quality, natural gut leader will probably cost you 50 or 60 cents. Such a leader is nicer to cast than one of imitation gut, as even when wet it has a faint springiness which tends to keep it from landing in a mass. Its superiority in this respect is important only in fly fishing.

The sizes of natural gut are usually listed by name instead of by breaking strain. Regular, fina, and refina, testing respectively about 5, 3 and 2 pounds are the only ones that need interest a beginning trout fisherman. Drawn gut (passed through a die and drawn to a finer size) is listed differently. Size 2x tests about $2\frac{1}{2}$ pounds, 3x tests about $1\frac{3}{4}$ pounds, and 4x (not recommended for beginners) tests about $1\frac{1}{4}$ pounds. All of these breaking strains are only approximate—different manufacturers do not agree closely.

Tapered leaders are made by carefully graduating the thickness of the pieces of gut knotted together. Such leaders have two advantages: They are easier to cast with and the inevitable snag usually takes only the last section. Short lengths of gut (called tippets or leader points) can be carried for repair purposes.

A good leader for most southern California use is a 6-foot one, either of natural gut tapered to refina (2 pounds), 2x ($2\frac{1}{2}$ pounds) or 3x ($1\frac{3}{4}$ pounds), or else of imitation gut, untapered, and testing 2 to 5 pounds.

In general the longer your leader the better your chances, but for bait fishing in southern California streams there is seldom any need for a leader longer than six feet and if you are fishing a very brushy creek you may find that even six feet is more than you can handle, thanks to low overhanging limbs. In such streams a 3-foot leader is usually long enough to fool some fish and short enough to enable you to reach under the limbs. If there are just a few bad brushy spots you can manage by reeling part of a long leader through the upper guides of your rod, but before you do this remember that the leader is apt to catch and refuse to pay out again until you coax it out by hand.

The color, if any, of a leader is not important so long as it is not conspicuous.

All leaders must be soaked in water before use. A new one may require a full half hour's soaking, but after being used it will soften up in a few minutes. You can soak your leader in a dish of water or by placing it between two moist pads.

Natural silkworm gut comes from Spain. There is already a serious shortage, thanks to the Spanish civil war. By the opening of next season (May 1, 1938) most of us may be using imitation gut regardless of our choice in the matter. The imitation gut, by the way, all comes from Japan.

Flies

A beginner who is teaching himself will do well to learn how with bait, but a few artificial flies are always handy. The following patterns should be enough: Royal Coachman, McGinty, Gray Hackle, Black Gnat, Mosquito, and one or two designs of nymphs or creepers. Size 12 is best, or sizes 10, 12 and 14 if you want an assortment. By all means get eyed flies, *i.e.*, ones on which there is a metal loop on the hook itself to which the leader can be tied direct. Snelled flies (the other alternative) have a short length of gut, to which the leader is fastened. Usually this snell is too heavy for best results, and in addition it usually deteriorates and breaks off long before the fly is past using.

Spinners

A spinner is a blade of metal, shaped much like the bowl of a teaspoon. When dragged through the water it spins like a small propeller. In fairly large pools, or in lakes, it is often very successful. For stream use get one with a blade about a half-inch long. Silver, copper, brass and hammered bronze are all excellent. In southern California streams, spinners are usually a last resort rather than a first choice, but by all means have two or three with you. The "Colorado" type is probably the best.

A combination that works well at times is a spinner to which a gaudy fly has been fastened.

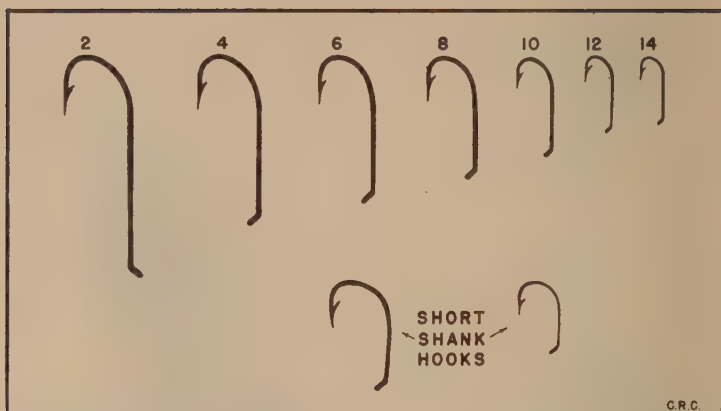


Fig. 24. Hooks, shown actual size. The longer shanked hooks shown here are a good shape for most bait fishing. The No. 2 has an up-turned eye, the rest have down-turned eyes. The two short-shanked hooks are shapes preferred by some for live bait fishing. The smaller short-shanked hook is an excellent size and shape for salmon egg fishing. Different makers' hook sizes do not agree perfectly. For example, some firms label as No. 14 a hook which is as large as another maker's No. 12.

Hooks

Hooks, like flies, can be purchased either eyed or snelled. If the attached snell (piece of leader) is long and fine the combination may be satisfactory, but in general, eyed hooks are better. Either up-turned or down-turned eyes are satisfactory, but ringed hooks (with a large eye not turned either up or down) are not. The writer prefers upturned eyes. Good hooks cost about 25 cents a dozen. Don't get the 15 cent a hundred kind; they are not at all satisfactory in the sizes used for trout fishing. Figure 24 tells more about the best shape than words could.

The sizes which are most useful are No. 14, 10 and 8. Two No. 14 hooks (one on the end of the leader and one an inch above it) make an excellent rig on which to drape a worm. Another good worm rig is a No. 8 or 10 with a No. 14 above it. (See Fig. 27.) A No. 10 by itself is excellent for either worms, salmon eggs or grubs. For salmon eggs a short shank hook is best. A few larger hooks, such as sizes 6, 4 and 2, are handy if the stream contains large trout and the fisherman has ideas involving the use of less conventional baits such as minnows, frogs or water beetle larvae.

Sinkers

In general the less lead you can get along with the better, but there are many times when it is needed. Split BB shots are the usual form in which it is sold to trout fishermen but thin sheet lead is far better. Cut the sheet into strips weighing as much as seems necessary and fold or twist them around the leader a foot or two above the hook. The equivalent of one or two BB shot is usually enough.

Landing Net

This piece of equipment is omitted by about 99 per cent of southern California fishermen. The writer is in the other one per cent, but does not insist that the net is absolutely necessary. Southern California fish run small and if you do get a big one you can usually beach it. If you are laying for a big one, you had better take a net along.

Fishing Basket or Creel

Fish do not keep well in a sack or on a string. Get a creel. You can get one that will do for less than a dollar or a really nice one for \$2.50. A strap (if you want one) will cost \$0.35 to \$1.50 more, but some fishermen prefer to carry the creel in one hand and set it down when going into action.

Tackle Box

Get a tackle box small enough to carry in your creel or pocket. Aside from that, let your conscience be your guide. A few aspirin boxes kept in a small jar will do nicely.

Leader Box

By all means have a box or pouch in which to keep spare leaders and leader tips. Moist felt pads will keep the leaders wet enough for immediate use. The box should be of some nonrusting material, since rust ruins leaders. Price, from 25 cents up.

Clothes

A trout fisherman who starts up stream at daylight has two alternatives. He may dress warmly—and have that extra sweater on his hands for three-fourths of the day, or he may shiver for the first hour or two. The choice is yours.

Suit yourself in the matter of dress—but wear something that won't be too conspicuous against a neutral colored background of leaves, dirt and rocks. **Don't** wear white.

Don't wear shoes that water will damage. Tennis shoes are excellent if you don't mind wet feet, but ones which have smooth soles or crepe soles will slip on wet rocks. Waterproof hiking boots are excellent. You probably won't need to go in far enough to run water over the top of a 14- or 16-inch boot. Rubber boots are out—you have to walk too far.

And don't forget to carry a knife.

Care of Tackle

Rod

Don't leave your rod standing outside overnight in the dampness. Dry the rod before you put it away.

Don't seal the rod in an air-tight case if it or its cloth bag is the least bit damp.

If the rod develops a "set" (bend) put it together and hang it up by its tip and leave it till the next time you want it.

Keep your rod well varnished—once a season is usually plenty. Repair any defective silk windings before varnishing. Any good tackle salesman will sell you varnish and silk, and tell you how to use them.

Don't store a wooden rod near a steam pipe, register or stove. The heat will ruin it.

Line

Don't leave the line on your reel between trips. Coil it up in a moderately loose coil and leave it in a cool dry place.

Reel

Clean and oil your reel once in a while.

Keep it out of the sand while fishing.

Leaders

Don't store leaders with hooks on them. The hooks may rust and ruin the leaders.

Don't get oil on your leaders.

Throw away any leaders (or parts thereof) that are frayed and fuzzy, or cracked.

Leaders which are new or in good condition at the end of one season, will be in perfectly good condition the next season. That statement will be regarded as rank heresy by tackle dealers but it is true.

Flies

Keep flies where moths can't find them.

Dry them out so rust won't spoil them.

Steam will fluff out matted flies.

Hooks

Make sure the points are needle sharp before you start fishing. A hook hone or a small sharpening stone will enable you to put a good point on a hook in a few seconds.

A little care will prevent rust from starting in a box of hooks. Dry hooks off before putting them away, and keep used ones separated from new ones.

Knots

Special knots are needed for tying leader material. (See Figs. 25, 26 and 27.) It is very slippery and with some knots it has a tendency to cut itself. Imitation gut is the worst; it is so slippery that a square knot or a sheet bend, for example, will not hold it at all. Hence, the need for some special knots that **will** hold.

Both natural and imitation gut must be thoroughly soaked before any knots are tied in them.

Pull all knots tight before using them. Pulling on the ends that are to take the strain usually tightens a knot tied in natural gut, but imitation gut often slips instead of tightening, even when it is pulled up moderately tight to start with, so pull firmly on **all** the ends and make sure the knot is tight.

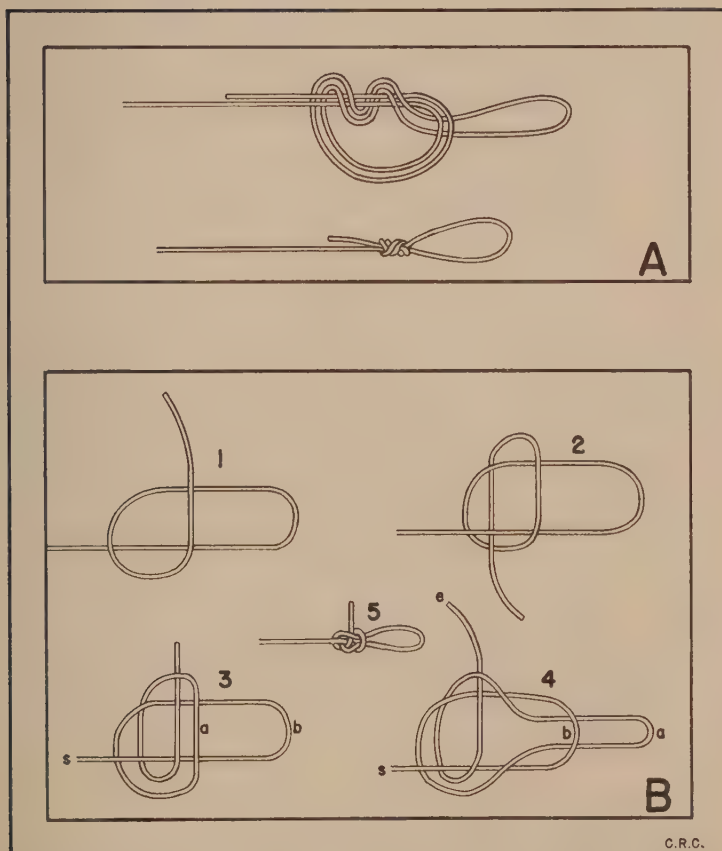


Fig. 25. Loop knots. Both are suitable for either natural or imitation gut.

A. Loop the end of your leader, tie an ordinary overhand knot with the doubled part, then pass the doubled end through the loop a second time and pull tight.

B. When you reach stage 3, hold as much of the knot as possible between thumb and forefinger to prevent slipping, then grasp loop "a" and pull under "b," thus reaching stage 4. Continue to pinch between thumb and forefinger and take up slack by pulling on standing end "s," then tighten by pulling on loop "a" and short end "e."

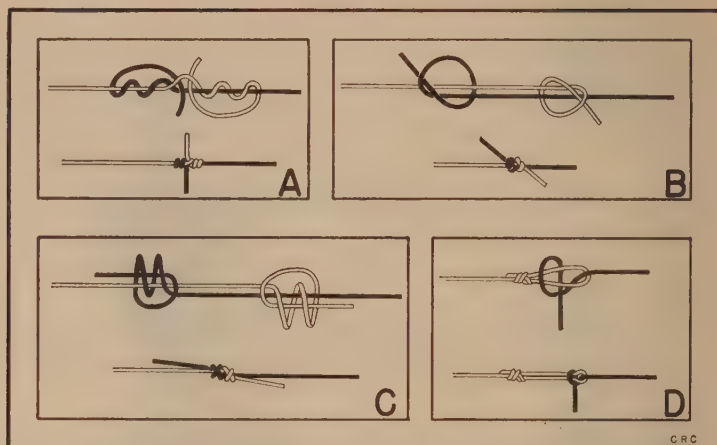


Fig. 26. A. Blood knot. This is the best knot you can use for tying together two pieces of natural or artificial gut. Its advantage is that the short ends of gut point at such an angle that they do not pick up stray bits of pond scum or rotted plant fibers. Its disadvantage is that in a dim light with half-frozen fingers you may not be able to tie it. You don't need to tie the blood knot exactly as it is shown here—an extra turn or two won't hurt anything.

B. This is a very easy knot to tie, but the short ends will pick up pond scum, etc. The knot is perfectly satisfactory for natural gut but not for imitation.

C. This is essentially the same knot as "B" but has an extra turn on each end. It is perfectly satisfactory for natural gut and with care can be used for imitation gut. When tying this material be sure to pull all ends tight and then pull hard on the long ends to make sure the knot is holding.

D. This knot is used to fasten the line to the loop in the end of your leader.

Rigging Your Tackle

The steps are as follows:

1. Put the leader to soak. This should be done some time in advance.

2. Put the rod together. Take the bottom two sections, line up the guides accurately and slip the ferrules together. If the guides of the two parts are not in line, pull the two sections apart and try again, but never under any circumstances twist a split bamboo rod. When the bottom two sections are together, rest the butt on the ground and slip the tip into place.

3. Attach the reel and make sure it is turned so the handle is on the side where you want it.

4. Thread the line through the guides and make sure that you don't miss any guides or take a turn around the rod with the line. This sounds like superfluous advice but it isn't, as can be testified by any one who has put his tackle together in that icy period just before dawn.

5. Uncoil the leader (this requires patience) and tie it onto the line.

6. Fasten on your hook or lure.

7. Bait up and get busy.

Taking the tackle down should be done in the exact reverse order. If your rod joints stick together get some one else to help you pull if

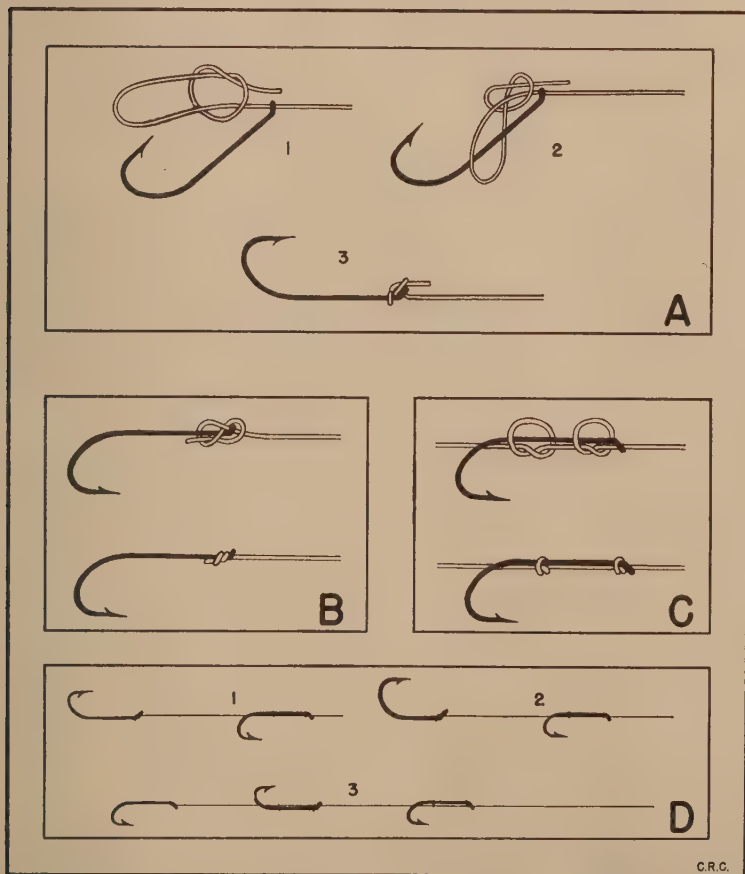


Fig. 27. A and B. Both these knots are satisfactory for tying an eyed hook to the end of a leader. They will hold either natural or imitation gut.

C. This knot serves to hold a hook above the end of a leader and is used in making up two- and three-hook rigs such as those shown.

D. Two- and three-hook worm rigs. No. 1 is probably the most generally useful. If your worms are very large you can space the hooks farther apart than shown here. No. 3 is a very deadly rig indeed but is not recommended unless you are fishing for some expert bait stealers, as ordinary unsophisticated trout will usually swallow the bottom hook. As a general rule, the more hooks you use the more snags you will catch.

necessary, but remember, **don't twist**. Sticking joints can usually be cured by applying a trace of grease or oil to the ferrules before putting them together. Rubbing the male ferrule against the side of your nose will usually be enough.

LEARNING TO CAST

Put your outfit together and go out on the front lawn—oh, all right, the **back** lawn then, if you are that sensitive about it.

Drop or Underhand Cast

Hold the rod in one hand, the bait in the other, and have the line from bait to rod tip sag just slightly. Point the rod at the horizon. Now drop the bait and simultaneously lift the rod tip. The bait should swing away from you, first down and then up. As it starts to rise, drop the rod tip and the bait will keep on going and land on the lawn somewhere in front of you. Practice till you can drop your bait exactly where you want it nearly every time. On the stream you will have to hit the spot you are aiming at, and will have to miss limbs and snags in order to hit that spot. This is the simplest of all casts, but for bait fishing it is by all odds the most useful. On a small moderately brushy stream at least 90 per cent of your casts will be of this type.

The Overhead Cast

This is **the** standard cast for fly fishing. You can get real distance with it when using a fly or small spinner. You can cast bait fairly well, but are all too apt to snap the bait off the hook. It is a last resort bait cast for that reason.

Flip your line as far in front of you as you can, then lift the rod tip to vertical with a bit of a snap. Your line will fly out behind you. Just as it comes tight in mid-air, snap the rod forward again, the line will land on the lawn in front of you. Now strip a yard or so of line off the reel and hold it in your left hand. Make another cast just as you did the last one, but when the line is flying forward let go of that yard or so you have in your hand. The momentum of the moving part of the line should pull this extra three feet out through the guides; if it does, feed it another yard on the next cast, and so on.

The trick to overhead casting is in the timing; you must learn to start the forward cast just as the line comes tight behind you. If you start just as the momentum of the line springs the rod tip backwards, the line will get flipped forward by the spring of the rod in a way no amount of power on the swing can duplicate. To learn the proper timing, watch your back cast—it shouldn't take you many minutes. If you start too soon you will "crack the whip" with your leader and may ruin it. If you start too late there will be a double jerk as you cast, and the cast will lack power. The first jerk is the line coming tight behind you and getting flipped weakly forward by the rod alone; the second jerk comes when your swing takes up the slack.

A few hints on the overhead cast: Use your wrist, not your arm. Remember the cast goes as far behind you as it does in front—so make sure there is plenty of room. When you make your back cast, remem-

ber to stop the rod when it is vertical, or a very little past that; many self-taught fishermen never do learn to cast properly because they persist in swinging the rod back till it points almost horizontally behind them. Try to keep the line high in the air on your back cast. When you want a fly to land with great delicacy, don't cast **at** the spot you want to hit, cast at a spot two feet above it and let the fly settle to the surface.

Side Cast

When there are trees low overhead you can often use a side cast. Except that the rod is swung to one side the method is a duplicate of the overhead cast.

Special Casts

There are several other casts designed to get distance without the need for a lot of space behind you. They are not used often and the beginner will do well to really learn the casts just described before he starts worrying about anything more complicated.

HABITS OF TROUT

Trout are found in cool or cold fast-rushing streams and in clear lakes. They are not found in sluggish lowland rivers or in excessively warm and weedy ponds and lakes. They must have cover; they like to hide under rocks, under banks, in log jams and among roots. Unless there are such hiding places available trout will not thrive. In California most of the trout streams which are under 4000 feet in elevation, are in shady canyons and almost all canyon streams which flow the year around contain trout. In the higher elevations there are open meadow brooks which provide excellent sport, but in the lowlands such streams are usually too warm and sluggish. There are some streams which cut across the narrow coastal plain and empty into the ocean. If the river bottom contains boulders and gravel and the water forms pools and riffles, there may be good trout fishing right down to the ocean, but there will be no fishing at all in the lower reaches of the river if the bottom is sandy and the water is smooth flowing and of uniform depth.

California streams have a tremendous seasonal change in rate of flow, and many that are rushing torrents in February are nice looking trout streams in May, and by August are reduced to strings of pools with no water at all flowing above ground. In such streams, the isolated pools are often teeming with trout. Of course, when all the streams vary so much in flow there are many which dry up entirely—make sure the one you are planning to try out is not one of these. Southern California streams are more prone to dry up than those in other parts of the State.

Food Habits

In California, stream trout feed primarily on aquatic insects and insect larvae, crustaceans (shrimp, etc.), mollusks (clams and snails), land insects which have fallen in, and to some extent on small fish. Some large trout, usually brown or Loch Leven, feed largely on small

fish and do not hesitate to include any small trout that may stray within reach. In most southern California streams, aquatic insects and insect larvae form the bulk of the food, and the caddis worm is probably the commonest single item. This creature is the larva of the caddis fly. Most caddis fly larvae live in cases which are made of bits of wood, sand grains, etc. These cases are quite conspicuous and abound in most trout streams. The fish frequently eat the "worm" case and all.

Trout food is most abundant under stones, logs and other obstructions in the rapidly flowing parts of the stream, and the trout himself is essentially a fast water feeder. A feeding trout will usually be in or near fast water and will also be in or near a good hiding place. In a large stream, he may be in the open riffle if it is not too fast but he is more apt to be where a boulder breaks the current. He may be under a bank, or in the deep water at the head end of a pool, but wherever he is he will be watching the fast water and will be waiting to grab whatever the current brings him. In a small brook the riffles are usually too shallow for safety or comfort and the trout will probably be at the upper end of a pool, watching the fast water flow in. Wherever he is in a large stream or small, if there is any current he will be facing into it. If he is in an eddy, that may result in his facing down stream—remember that when you sneak up on him. A trout in the middle of a large quiet pool is usually loafing. He is not overly hungry and tends to be very critical of all offerings, and as the water is clear, the surface is unbroken, and the visibility is excellent, he usually shows unerring judgment in separating free offerings tossed in to whet his appetite from those which have a hook in them.

During the legal fishing hours (one hour before sunrise to one hour after sunset) trout seem to feed best in the morning and evening. The middle of the day is quite slack by comparison, but it is by no means useless to fish at midday. The big cannibalistic trout seem to prefer the hours of darkness for their depredations, but even they will occasionally bite at noon. Probably one thing that helps make the trout **seem** to be off their feed at noon is the excellent light which makes even a fine leader stand out all too clearly.

Size of Southern California Trout

Small streams contain small trout. In most southern California streams even the larger pools are seldom much over 30 or 40 feet long. In such creeks, a six-inch fish is the most usual, anything over eight inches is a good one, and anything over ten inches is something to crow about.

Some of the larger streams have deep pools over a hundred feet long. In such places there are sometimes a few trout as large as 20 to 22 inches, but as far as the beginner is concerned, they are there for ornamental purposes only. They didn't reach that size by being careless, and until he learns how to look for them the beginner may not even see them.

Wherever you fish in the southern part of the State, any stream trout over a foot long is a beauty—and you needn't be ashamed to keep the six-inchers.

If you get a really small one and wish to throw him back, notice first if he is bleeding at the gills. If he is, **keep him** regardless of size.

If he is not injured, you can often turn him loose by holding the hook upside down and shaking it. If this won't work, wet your hand and hold him gently while you unhook him. If you do this properly he will live to grow up—or, more likely, to go into the creel of some one who is less particular.

Steelhead

There are a few southern California streams, such as the Ventura River, which have good trout water right down to the ocean, and there are some others which have a good flow down to the ocean in the winter time. During flood periods, such streams are ascended by large sea-going steelhead trout which usually spawn and return to salt water long before the fishing season opens. However, there are often a few steelhead which do not get back during high water and which are forced to spend the summer in the stream. Such fish are sometimes over 30 inches in length and 10 pounds in weight. Don't expect to catch one—but don't drop dead if you see one! Southern California is the extreme southern limit of the steelhead's range. If you really want to catch one go north at least as far as the Eel or Klamath rivers. Incidentally a steelhead is a trout—any trout—which has gone to sea. It is **not** a separate species even though it does look it.

BAIT

Worms

The most time honored of all baits is the old reliable earthworm. Its reputation is well deserved—it works very well indeed. Earthworms can be purchased at almost any sporting goods store in southern California. If they are kept reasonably cool and are occasionally sprinkled with a few drops of water, they usually stay alive for two months or more. Even if you plan to dig your own, it will pay you to look at and into a can of "store" worms. You will probably get some ideas on how best to keep your own alive.

Garden-dug worms should be starved for a day or two before use. This cleans them out and toughens them up a bit. A good method is to pack the worms in damp (not wet) moss or shredded paper towels. Put a lid on the can but have a few small air holes in the lid.

Warning! When you take worms to high altitudes don't leave them outside at night. It may freeze and kill them. Wherever you are don't leave worm cans in the sun, close to the motor or exhaust line of your car or any place that will overheat the worms.

When you put a worm on a single hook, put the hook through him once or at most twice and let most of his length dangle. **Don't** get him so firmly onto the hook that he can't even wiggle and don't thread him onto the hook. It is not necessary to hide the hook clear inside the worm, but if snags abound where you are fishing it is advisable to cover the point. When a trout bites give him a few seconds to get the entire worm in his mouth, then strike. If you strike too soon, you will probably donate him half the worm.

If you are using one of the two- or three-hook rigs, shown on figure 27, drape your worm over the hooks without putting any sort of a loop in him. When you get a bite, strike immediately.

Salmon Eggs

In this State canned salmon eggs are even more commonly used than earthworms. They will keep until the can is opened, but will start to mould not many days after that. In the writer's estimation they are not nearly as good a bait as worms, but they do have one great advantage for a beginning fisherman: They are so conspicuous that it is very easy to watch the course of one through the water. This enables you to keep track of your bait and to learn much more quickly what that bait is apt to do in different types of currents and eddies.

The best hook for a salmon egg is a short-shanked one which nearly fills the egg. Too small a hook is apt to jerk out and leave the egg in the fish's mouth. Size 10 is best for average sized eggs.

Insects and Insect Larvae

If you run out of the two standard baits, don't hesitate to use grubs, caddis worms, stone fly larvae, grasshoppers, or anything else you can find. Most such baits are quite small, but don't let that bother you—it won't bother the trout. Use a small hook and don't insist upon hiding it in your bait. If the bait is very small, very fragile, or has a very tough shell it is best to leave the point and almost the entire bend of the hook exposed.

Fishing with grubs *et al* is a very complex game and to do it really well requires a great deal of skill and experience, but it will often catch fish when nothing else will work at all. The beginner may not do it properly but even so he may get reasonably good results while learning.

Those funny looking inch-long bundles of sticks or sand grains that you see in the stream are caddis worm cases. Extract the worm and use him for bait.

The best place to look for bait is under rocks in shallow water which is moving fairly fast.

FISHING

How to Approach the Stream

All too many fishermen walk up to a trout pool with no more care than they would use in going to the corner drug store, and wonder why they never even see a fish. Move as carefully as though you were stalking game and you will have much better "luck."

If the water surface is glassy smooth, stay back of a bush, rock or tree. If you can't do that stay in dense shade and move slowly. If there is no shade creep up on hands and knees, or at least contrive to have something besides sky for a background. If there is no cover of any sort stand well back from the stream. **Never let your shadow fall upon the pool.** If you are so dressed that you harmonize with your background you can often stand in full view of well educated trout without frightening them—but you will have to move very slowly to do it.

If the water surface is ruffled you do not need to be nearly so particular, and if the water is white with bubbles or is muddy, about all you have to do is to avoid casting a shadow on the place where you are fishing.

Remember that trout face into the current. A trout is less likely to notice you when you are behind him.

Often, in spite of every care you can take, you will frighten the fish. When this happens it is usually best to move on, but sometimes the frightened trout are worth waiting for. Get yourself into a comfortable position and wait quietly. Usually the life of the pool will return to normal within five to fifteen minutes and you can get results.

Talk, shout or sing all you please, but **walk** quietly. If the stream is quiet and unbroken take every precaution to step lightly, and remember that the ground carries sounds for long distances. A stream with under-cut banks is the very hardest to approach. In such a place even your best efforts may not be enough. In places where the water is tumbling noisily along you do not need to be nearly so careful.

In general, don't wade southern California streams while fishing. In very large streams it is often necessary to wade in order to reach the fish with a reasonably short line, but there are very few places in southern California where the practice is in the least desirable. If you **do** wade while fishing be sure to move slowly enough so that you don't splash at all.

Offering Bait to a Trout

Use one bait—not more. A second hook and bait is apt to alarm a suspicious trout and will transform the rig into an excellent snag collector.

A hungry trout in a flowing stream is usually watching for anything edible that the current may carry within his reach, so let the current carry your bait past places where a trout is likely to be waiting. Drop your bait a few feet up stream from the place you hope to get action and let the current carry it along on a moderately slack line. Too tight a line will not permit the bait to act naturally and too much slack will make it hard to tell when you have a bite. If possible move the rod tip along above the bait. This insures a slack line and yet makes it possible to use a very short line. The drag of the current on a long slack line sometimes keeps the bait from acting naturally, particularly if you are casting across the stream.

Remember that a loose worm, salmon egg or grub will usually drift along pretty close to the bottom, so make your bait do likewise and your chances will be far better than if it stays in the upper layers of water.

Where there is a waterfall dropping into a pool toss your bait into the fall and let it drift around in the pool. If the current carries it along one edge of a pothole, let it drift to the lower end (if it will) and then throw it into the fall again and steer it so that it will go across the middle or along the other edge. You may have to pull it a bit to get it started in the direction you want, but slacken your line as soon as the current starts taking it where you want it to go. The less pulling you do the better. There may be an eddy in the pool. Let your bait drift into this eddy.

When you come to a riffle flowing into a pool drop your bait at the upper end of the riffle if it is short or a few feet up if it is long, and, if possible, follow the bait with your rod tip till it is well into the pool.

If a long riffle is shallow and contains no pockets of deeper water, it should be passed up.

A long riffle which averages more than knee deep and has boulders scattered through it is often an excellent fishing place. Drift your bait into all the pockets back of the boulders. In a large stream you can often get excellent fishing in the riffles when everyone else is fishing the pools and getting nothing.

Whenever it is feasible, do your fishing with a short line but don't be afraid to use a long line if it seems advisable. Simply strip line off your reel and let the current take it out through the guides. If the current is not strong enough to do this, you can make line go through the guides by switching the rod tip back and forth. Sometimes when you want the bait to sink quite deep and drift quite a distance it is advisable to drop the bait, leader and a few feet of line in the water right at your feet and then switch your rod and feed line through the guides faster than the current will take it. In this way, a very long and very slack line will be sent down the stream. It will sink deep and often a naturally drifting bait will be presented to a trout which could not be reached by any other method. However, remember that a long slack line is very apt to hang up on a snag—so look the water over first.

Use of Sinkers

In general the best rule for the use of lead to sink your bait is **don't**. However, when the current is very swift there are many times when you simply can't get your line to sink. In such cases, pinch a tiny piece of sheet lead (or one or two split shot) onto the leader a foot or two above the bait. If more is necessary use more. By all means use enough to get to the bottom of a good looking hole, but when you move on to a place where the lead is not needed take it off. Bait will not drift naturally if it is dragging too much weight, and you will catch far fewer snags if you take that weight off.

How Long to Fish in One Place

One of the major worries of a beginning trout fisherman is whether he should spend two minutes or two hours at that nice looking pool. The following is an attempt to give a rough idea of about how long it is worthwhile to fish in one place **if you don't get any strikes**.

A narrow glide, three or four feet wide, or a pocket back of a rock should never need more than two or three well-placed casts.

A pool, 20 feet long, 10 to 15 feet wide, and 2 or 3 feet deep, can usually be well covered by drifting the bait through it a half dozen times.

A larger pool in which most of the lower end is flat and shallow can be disposed of about as quickly. Fish the deeper water at the upper end and forget about the rest of the pool.

A deep and turbulent pothole, 10 to 15 feet across, is often worth a bit longer stay. Drop your bait in and let it drift around in the eddies or rest on the bottom for a minute or so after each cast. Four to six such casts should do.

Waterfalls which are 10 feet high or more will often drop into large deep potholes. Such places are excellent. Let your bait drift around for a total of at least five minutes and don't feel that you are wasting your time if you spend fifteen. There is apt to be a big sus-

picious trout who will be startled even by a careful approach, but who will quit worrying if you sit quietly in one place for five or ten minutes.

When really big pools are fished where the water rushes into them, they are treated much like a smaller hole. Let the current carry the bait in several times, let that bait drift as far as it will and leave it for a minute or two after it stops moving. If you need a rest, leave the bait there several minutes, then pull it in gently and be ready for action. Often a trout will swallow your bait and won't be noticed because of the slack line. Should you get no results you had better move on if fishing has been at all good. If fishing is poor or you are tired, you may decide to fish the middle of the pool. The cards are stacked against you, but you may get a beauty.

Climb to a spot where you can see well into the pool. Thirty to fifty feet up a steep bank will give you an excellent view and if you use a little care you won't frighten any fish. Look carefully. There may be a veritable school of trout loafing in the deepest water. Throw in a free sample of bait. If the response is a scramble for the bait, your chances are good, but if there is a scramble for cover you may as well move on. Chances are you won't get either extreme. Probably a trout will swim up to your bait—maybe he will take it, maybe he will let it settle to the bottom, perhaps while he is making up his mind a smaller one will sprint in and grab it. Having found out where the fish are and what the general attitude is, sneak up to a good spot where you can see what is happening and make yourself comfortable. Throw in a free sample and drop your **real** bait nearby. Perhaps some trout will make a mistake—odds are that if the fish are at all large they will take free samples and nothing else. Let your bait **and leader** settle to the bottom and rest there for some time. There is an excellent chance that after a short while some good trout will pick it up—probably because the leader is so much less conspicuous when on the bottom.

No matter whether you are fishing a tiny riffle or a huge hole, if you get a strike try again. If a fish gets your bait without being hooked, he is almost certain to bite again. If you hook a nice one and lose him try again right away—the danger may not have registered on him. If he is frightened, stop fishing for him and try again later. Fishing for an alarmed trout only serves to confirm his suspicions. If a fish strikes several times and then stops, move on but remember the place and try again later. If you land a fish try the same spot again. You may have frightened all the others in the pool—and you may not. It is a common occurrence to fish a quarter-mile of stream without a bite and then to get three or four out of a hole that looks no better than average. After you catch one fish, it is often a good plan to wait a moment or two before trying for the next one. One expert carefully cleans each fish as soon as it is caught, buries the entrails, and then tries for the next one. He finds that the cleaning operation takes him just about the right length of time—and in addition it gets the fish home in excellent condition.

A general rule on how fast to fish a stream: If fishing is fair or good you can usually catch the most fish by covering the stream rather rapidly, but by a slow and careful working of the better looking spots you will probably get larger fish. A good compromise method is to rapidly cover all but a few of the very best spots and spend some little

time at each of them. If fishing is very poor you will probably do best to fish rapidly until you see some good trout and then use all your patience and ingenuity on them.

Hooking and Landing a Trout

Whenever you drop your line into the water watch the bait if you can do so without showing yourself to your proposed victims. If the bait suddenly vanishes without any apparent reason, it was probably grabbed by a trout. An eight-inch trout is often far harder to see than a salmon egg or even a worm. If you can't see your bait, watch your line. If it starts to move erratically, you probably have a bite. This movement may be anything from a faint twitching to a steady march against the current. An inch or less of white or red string tied to the upper end of the leader will often be a help in detecting a bite—watch the string for erratic movement. **Even if you have no reason to suspect a bite be ready for action whenever you pull in slack line.** All the time your bait is out keep your finger tips alert. Feel for a faint rapping as well as for a more violent bite. If you think you do have a bite, pull in your line gently but fairly rapidly until you feel your fish, **then** set the hook. If you strike while there is several feet of slack line in the water you will warn the fish and he may be able to spit the bait out before you get the line tight. When you do strike be gentle, remember you are not trying to throw him over your shoulder, you are only trying to drive in that tiny needle-sharp hook. A jerk that will sail a six-inch trout through the air will snap a fine leader if the victim is 11 or 12 inches long. When your fish is hooked, pull gently and keep pulling. If he is a small one you will lift him out. If he is fair-sized he will probably start to go places. Let the line slide through your fingers or off the reel with enough pressure to put a good arc in your rod, **and keep that rod bent.** Its spring is the best safety device known against sudden stunts by the victim. If the fish heads for a brush pile or some other place that spells disaster tighten down on him and stop his rush. If he is a really big one, and you can't stop him without danger of breaking the leader, let him run. A trout tangled in a brush pile is not hopelessly lost. The biggest stream trout I have seen taken in southern California was hooked by a friend and was finally netted by the writer in a mass of roots in about six feet of water. Due to too hasty shedding of underwear there were buttons scattered all over the bank. The trout was worth it—just over three pounds. If your trout doesn't reach cover or come unhooked he will soon be lifted to the surface by the steady pull of the rod. Then, if he is under eight inches lift him ashore. If he is over 10 inches, find a bit of beach to slide him up on. If he is over 12 inches, don't beach him till he is thoroughly exhausted. If there is no beach get him completely fought out and use your creel or your hat for a landing net or grab him by the gills. It is a good idea to spread a handkerchief over your hand before grabbing—cloth which is free of fish slime won't slip at all easily on a fish. If by any chance you **do** have a landing net, you can use it much earlier in the game than it would be safe to use a creel or hat.

Rudiments of Fly Fishing

The beginner who really wants to learn fly fishing should by all means get some one to teach him, but if he just wants to do a little experimenting with a fly between spells of bait fishing the following should be of some help.

One of the most important differences between fly and bait fishing is that when a trout grabs a fly he immediately realizes that something is wrong and spits it out. This means that a fly fisherman must always be prepared to strike instantly. One trick (frowned upon by fly purists) is to put about an eighth of an inch of worm on the hook of your fly. A trout will hesitate an instant before spitting this out and you will have a bit longer in which to strike, but even with a baited fly the strike must be fast and any amount of slack line is out of the question.

Nymph and creeper flies are excellent for a beginner's use. They are made to represent the aquatic larvae of insects, and can be fished much like bait. Let them drift around near the bottom just as you would bait, but keep your slack down to a minimum, watch your leader like a hawk and strike at the first faint twitch. Other types of flies can be drifted near the bottom in this same way but are more commonly used on or near the surface. Surface work has to be done much more skillfully but you do have the advantage that you can usually see your fish coming. When you do see a fish dart for a fly don't wait for him to hit it but strike right then. The lag of your reflexes and the slack in the line will give him time to reach the fly.

If your drifting fly, nymph or creeper doesn't get any action retrieve it slowly with a faint twitching motion. This will often attract a fish that had failed to notice it. Try to make it act like an insect struggling against the current or swimming across quiet water.

Cast into the base of a waterfall and twitch your fly away from there like a half-drowned insect trying to reach shore.

Cast across the current and let the force of the water against your line whip the fly downstream and across. Try moving your fly along the surface of still water at a speed of one or two miles per hour. Pull it against the current, but do this very slowly.

Dry fly fishing consists of floating the fly on the surface and letting it drift naturally with the current. The method is most effective at low water. In general dry flies should be cast upstream or up and across and allowed to drift down. Pick up the slack as it comes toward you.

To float properly a fly must be dry. If it gets soaked blot it and then make a few false casts (casts which do not touch the water) to finish drying it. A few false casts after each real cast will usually keep the fly dry enough to float. Use of fly oil is also a help in this matter.

Often when everything else fails you can make a trout strike by letting your fly dangle below the rod, lowering it till it just touches the water, then letting your hand tremble faintly. This makes the fly seem to flutter on the surface. The method is most valuable at extreme low water.

A fly fisherman will usually cover a stream a bit more rapidly than a man using bait. This is because the drifting of bait on a long slack line takes more time than any sort of fly cast.

Use of Spinners

In some regions, such as the coastal area from central California north, a well used spinner is murderous. In other places the trout just don't seem interested enough to strike hard. They will swim up and nudge the spinner but seldom get hooked. In southern California most of the streams are in the latter category and in addition many of them are so small that it is very difficult to fish a spinner properly. Some of the lakes in southern California are quite different—spinner fishing is excellent.

Spinners are fished by dragging them slowly through the water. The best speed is the very slowest one which will keep the blade turning properly. Spinners should be allowed to sink and then fished deep. An eighth-ounce or more of lead is often a great help in keeping one close to the bottom. As a general rule, fishing across the current is best but you can fish up stream or down if the current isn't too swift. A spinner doesn't have to pass as close to a trout as does a bait or fly. Its glittering blade will often attract fish from 10 or 15 feet away, thus making it possible to cover a large stream very rapidly. In small streams, on the other hand, a spinner is not satisfactory because it has to be moved rather rapidly to keep it turning, and it is clear across the pool before a trout has had time to decide whether or not he wants it.

Spinners are often useful at noon or during some slack part of the day when the fish are not taking bait.

Fish which are striking half-heartedly can sometimes be induced to hit harder by dangling a small piece of bait on the hook of the spinner.

Spinner fishing is the fastest of all methods of covering a stream. A fish that is in the least interested will nearly always come out and look at a spinner on the first or second cast, and if nothing appears you may as well move on.

ILLUSTRATIONS OF DIFFERENT TYPES OF TROUT POOLS

The text up to this point has been rather general. The following pictures with their captions are an attempt to be as specific as possible in telling a beginner where to fish.

To show the approximate size of two of the pools the writer's dog was induced to pose in the picture. She appears in a third on her own initiative. Perhaps this would be a good place to bring up the subject of dogs on trout fishing trips. No dog is an asset, and everyone's fishing will be utterly ruined by a hysterical pup that insists on dashing ahead and into every pool. A dog that will mind and can be made to stay away from the creek is not too great a handicap if you and he really enjoy each other's company.



Fig. 28. This is a typical small waterfall and shallow pothole combination. The best place for a bait fisherman is behind the rock "A." Drop your bait just above the waterfall and let it drift clear across the pool. Three or four casts should be enough. Steer your bait so that each cast drifts along a different route. Be sure to drift a bait along the base of rock "A."

Don't pass up the fast water at the foot of the pool. If you decide to fish it from rock "A" be sure the upper end of the pool is fished out before you start—a trout dragged the entire length of a pool is liable to frighten everything in it.

Spinner or fly fishermen would do better to stand below or to the left of the part shown in the picture, but back far enough so the fish won't notice them. Drag spinners clear across the pool just fast enough to keep them turning. Drop flies near the waterfall and let them drift. If that doesn't get results, try working the flies across the pool.



Fig. 29. This is a deeper hole than shown in Figure 28. It is an excellent place for bait but not very good for spinners. Drop the bait at "1" and let it drift through the hole three or four times. Make sure it goes deep and that on one or two casts it goes around the corner past "2."



Fig. 30. Trout may be anywhere under that large area of foam, so drop your bait in three or four different places, and each time let it drift across the pool by a different route. Let the bait boil around under the foam for a minute or so if it will stay there.

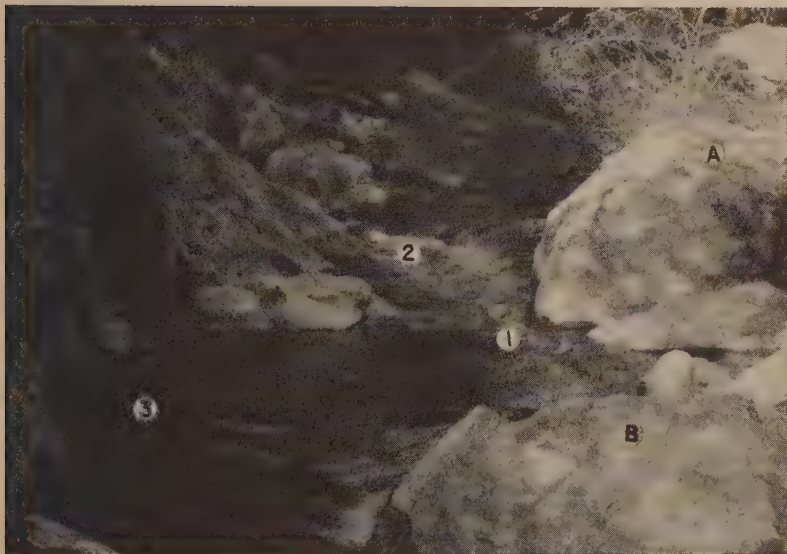


Fig. 31. Riffle and small pool. The best place for the fisherman is behind rock "A" because from that position he can easily keep any small trout hooked in the riffle from getting into the pool and disturbing other fish. Any fish much above "1" will probably be small and will be there because a bigger one has taken the best spot somewhere below him. Drop your bait in at "2," and follow it with your rod tip to let it sink deep before it reaches "1." Pay out as much line as is needed to let your bait drift the entire length of the pool. Make four or five casts and try to steer at least two of them into the eddy which flows from "3" toward "1." This will be hard and instead you may have to cast over to "3" or beyond in order to accomplish the same result. A bait which hits a rock and slides or falls in will be far less likely to disturb trout than one which lands in smooth water with a loud smack. If there were no cover at "A" the fisherman would be far better off fishing from behind "B" than standing or kneeling in the open at the upper end of the pool.

Fly fishermen should fish the pool in a way much the same as that just given. Drift flies with the current, then work them across and finally against it. Don't try to drift a fly to "3"—cast it.

Spinner fishermen will have no trouble fishing below "1" but the riffle looks too fast and too narrow for proper use of a spinner.

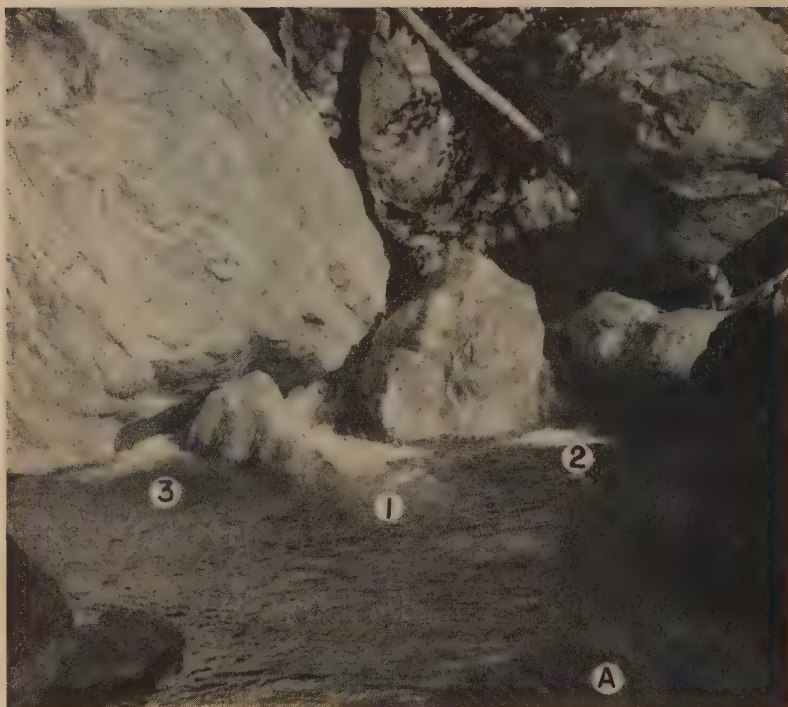


Fig. 32. This is a beautiful type of trout pool and one at which the fisherman could well afford to spend ten minutes or more, especially if he knows there are big fish in the stream. "A" is the best position from which to fish. "1" is the most likely looking place to drop a bait or fly, "2" is the next, and "3" is a bad third. Spot "1" should be fished first because anything hooked there can be led away without disturbing either of the other two. Try "2" next. Trout are apt to be anywhere in this pool, so cover it slowly and carefully. Let bait drift around all over the bottom; this process is apt to hook a good fish several minutes after all other action is over.

Spinner fishermen should use plenty of lead and keep the blade near the bottom. This is something which is always hard to do in steep-sided pools such as the one shown. Cover such pools thoroughly with a spinner, but do not bother to keep casting for minutes on end. Any fish that wants it will nearly always take it in the first eight or ten casts.



Fig. 33. This type of pool must be approached with great care. Water is running fast and smooth for its entire length. Trout may be anywhere and from most places they will have an excellent view of any careless fisherman.

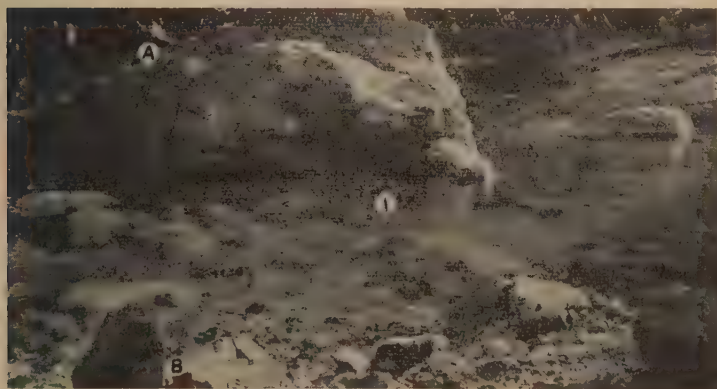


Fig. 34. This pool is another which must be very carefully approached, but it does have one advantage: you can watch your bait, fly or spinner and will have plenty of warning before a fish strikes.

If you are on the far bank start operations near "A." Try "1" first—there will probably be a trout loafing in the shadow—but he won't stay long if you show yourself.

If you are on the near bank crawl to "B" and stay down. Cast bait or fly well up stream from any trout you see and let it drift well past the fish before you pick it up. Cast a spinner up stream from and well beyond your fish—if you can do so cast it clear into shallow water near the far bank so the splash will be a long distance from the fish.



Fig. 35. The trout will be under the roots, so drift your bait close to the bank. If a fisherman gets on top of that bank his footfalls may frighten the fish and if he does hook one of any size, it is apt to be back among the roots in a flash. A safer bet would be to crawl up to the rocks "A," cast into the white water and let the bait drift close to the steep bank. Then a fish can be led away from the roots as soon as he strikes.

Fly or spinner fishermen should work from "A" or stand well back on the right-hand bank. Cast close to the roots, but don't overshoot and cast into them.



Fig. 36. This is the sort of place where trout may be anywhere but are more apt to be nowhere. A fly or spinner fisherman could cover this place fairly quickly by cross-current casts, but a bait fisherman would take much longer drifting his bait into each pocket. If you don't want to waste time doing this, try using an inch-long piece of worm and work it across the current like a fly. The trick often works on unsophisticated fish in shallow water.

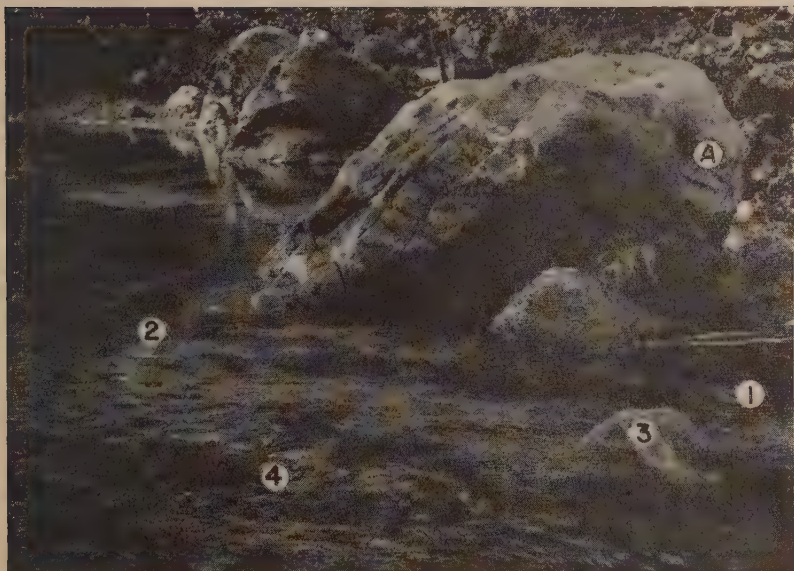


Fig. 37. This is another place where staying out of sight is of prime importance. Trout are apt to be anywhere in the smooth run between "1" and "2," below rock "3" or submerged rock "4." If you are fishing from near "A" cast your fly or bait up stream (above "1") and give bait plenty of slack so it will settle in the deep water near "2." Work close in behind rock "3." Let your line drift down stream from "4."

The current at "1" looks too fast for good spinner work, but if you are using a spinner try some short cross-current casts to make sure. Make these casts long enough so the splash is well beyond the place you want to fish. Cast up stream and across and retrieve fast. Make some long casts and let the drag of the current on your line whip the spinner down stream and across. Hold your rod tip high enough so the line passes over rock "3"; it will probably wash over "4" without any trouble. Make three or four long casts down stream from "2." If necessary, crawl onto the big rock "A" to do this but don't stand up.

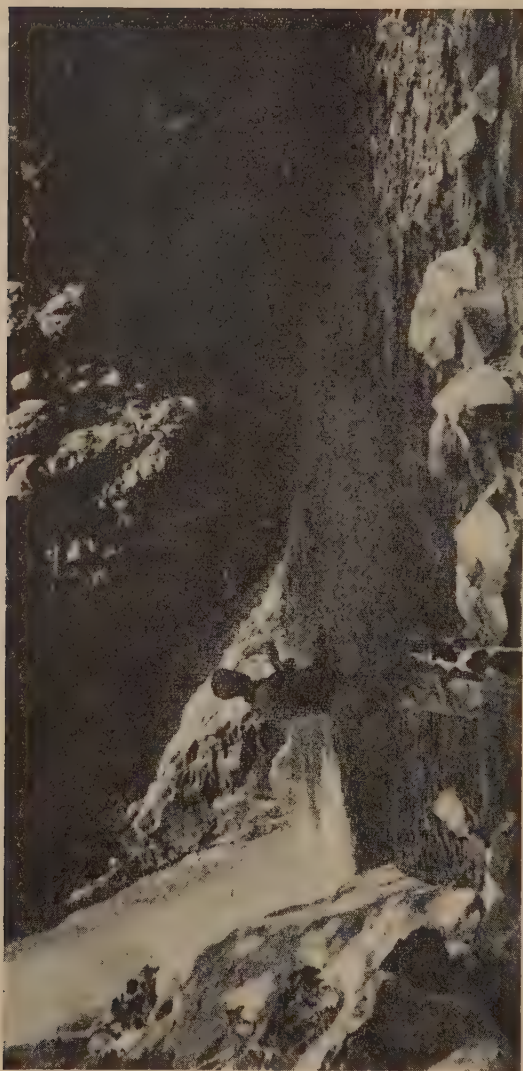


Fig. 38. This is an excellent pool for bait or fly, and is a spinner fisherman's delight. The water surface is ruffled enough so that extreme caution is not required. When this picture was taken the fisherman (an expert) had finished working the nearer part of the pool from a place farther back on the bank and had moved quietly forward to fish the deep water along the far edge. Results were excellent. When a pool of this type can be fished from the upper end it is a perfect place to let a bait drift for a long period, but when you cast from the lower end, the current with a long slack line to work on will usually drag the bait right out of the deep water.

A LIST OF TROUT STREAMS

This list does not pretend to be complete, but it does include a majority of the consistently good streams in southern California. Most of these streams have one or more forks which also provide good sport. With a few exceptions these branches have not been named separately.

Santa Barbara County

Santa Ynez River. Long stretches of this stream flow through cattle ranches, the owners of which do not permit fishing on their property.

Ventura County

Ventura River. This is a trout stream clear down to the ocean.
Sespe Creek.

Los Angeles County

San Gabriel River and all its branches. Due to diversion of water it is necessary to drive up the canyon almost to the junction of the West Fork.

Santa Anita Creek. Fish above the dam.

San Dimas Creek. Fish above the dam.

Little Rock Creek.

San Bernardino County

San Antonio Creek. Partly closed. All or nearly all of the closed part is in Los Angeles County.

Deep Creek. This stream is good clear down to the junction with Mojave River, but the fish are very well educated.

Holcomb Creek.

Santa Ana River. Good in the mountains—the lower reaches are barren.

Bear Creek	} Apt to be closed in midseason on account of fire hazard.
City Creek	

Riverside County

North Fork San Jacinto River	} Apt to be closed in midseason on account of fire hazard. Enquire first.
Strawberry Creek	

HOMING INSTINCT AND STRAYING AMONG STEELHEAD TROUT (*SALMO GAIRDNERII*) AND SILVER SALMON (*ONCORHYNCHUS* *KISUTCH*)¹

By A. C. TAFT and LEO SHAPOVALOV
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Indisputable evidence obtained through marking experiments carried out by various scientific workers in this and other countries has established as a fact the homing instinct among anadromous members of the salmon family. Briefly, young salmonids which descend from fresh water to the ocean return to their "parent stream" for spawning purposes (young fish artificially hatched and liberated return to the stream in which they were liberated, not to the stream to which their parents returned or in which they were hatched).

The present writers have had an excellent opportunity to study not only the homing instinct but also straying as exhibited by steelhead trout (*Salmo gairdnerii*) and silver salmon (*Oncorhynchus kisutch*) in California. Experiments in the marking of salmonids are not new to California. However, past work has been confined entirely to the king salmon (*Oncorhynchus tshawytscha*). These experiments are described in various papers appearing in *California Fish and Game* from 1916 to 1928.

Scott and Waddell Creek Experiments

Figure 39 shows the location of weirs maintained in three adjacent streams in Santa Cruz County by the California Division of Fish and Game, at which all steelhead trout and silver salmon (the only salmonids regularly present in the three streams) are examined. Young seaward migrants are regularly marked at both Scott and Waddell creeks,² so that the amount of straying between streams can be noted. The reader should note that upon descending to the ocean the young fish do not simply remain near the mouth of the stream of liberation, but may wander great distances. Marked salmon from Waddell Creek have been caught in the ocean off Fort Bragg, two hundred miles to the north (Taft, 1937). Incidentally, marked king salmon from both the Klamath and the Sacramento river systems, hundreds of miles

¹ The experiments described in this paper were in large part conducted in cooperation with the U. S. Bureau of Fisheries, as part of the program of the California Trout Investigations. We are indebted to Mr. Theodore J. Hoover for the use of Waddell Creek for experimental purposes, to Stanford University for laboratory space, and to Dr. P. R. Needham, of the U. S. Bureau of Fisheries, who is in charge of the cooperative investigations. Submitted for publication, December 31, 1937.

² For a description of the trout and salmon marking work carried on in California, showing numbers and sizes of marked fish planted, see Shapovalov (1937). In the present paper, the term "marked fish" refers to fish marked by clipping fins; "tagged fish" are those to which tags have been applied.

apart, have also been caught off Fort Bragg, and also in Monterey Bay (Snyder, 1921, 1923, and 1924), yet we shall see how accurately the homing instinct operates. It should also be noted that in general character, character of terrain, temperatures, chemical conditions, and rainfall, Waddell and Scott creeks are very similar.

Table 1 shows the various groups of fish marked and liberated at Waddell and Scott creeks, respectively, and the number returning to the parent stream or straying to the other stream. All of the salmon die after spawning once, so that no marked individual returns more

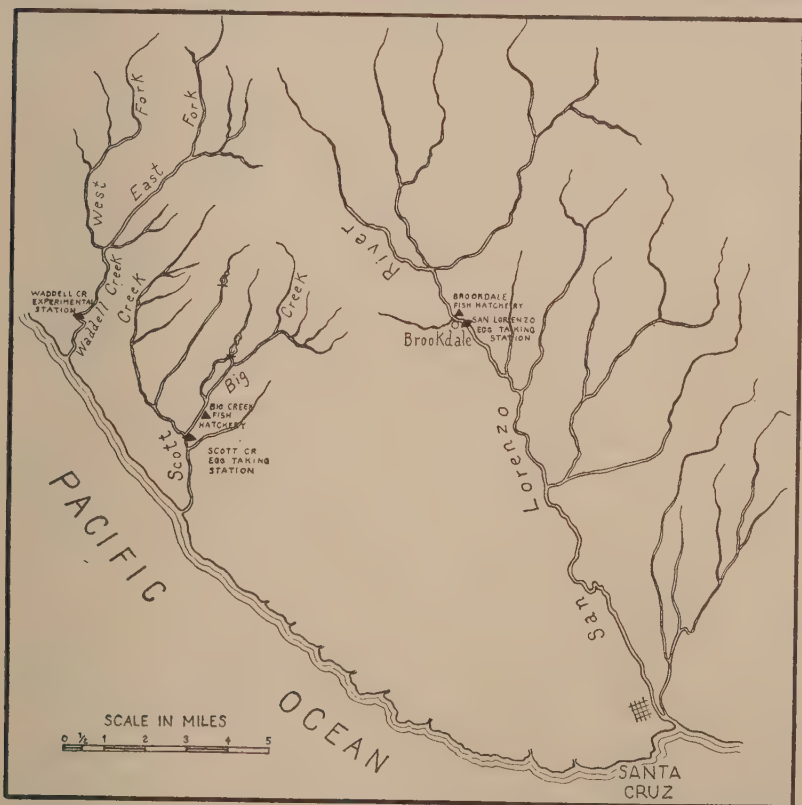


Fig. 39. Map of streams in Santa Cruz County, California, on which the California Division of Fish and Game maintains weirs.

than one time. Among the steelhead, the same marked individual may occasionally be present in successive years, but the number of such fish is quite small. Males and females have been grouped together in the table, since no significant sexual differentiation has been revealed in the straying fish as compared with those of the same year-class returning to their parent stream. The fish at Scott Creek are hatchery-reared, whereas those at Waddell Creek are naturally spawned. No "planting" of fish is done in Waddell Creek. For a description of the Waddell experimental station see Taft (1936).

TABLE 1
HOMING AND STRAYING OF MARKED STEELHEAD TROUT AND SILVER SALMON IN SMALL COASTAL STREAMS
Steelhead Trout

Season marked	Mark	Returned to Waddell Creek				Returned to Scott Creek			
		1933-34	1934-35	1935-36	1936-37	1933-34	1934-35	1935-36	1936-37
Waddell Creek—									
1931.....	Ad-LV.....	3 (100%)				0	0		
1932.....	Ad-RP.....				15 (100%)			1 (1.6%)	0
1933-34.....	Ad-LP.....			63 (98.4%)	39 (100%)		1 (1.5%)	0	0
1934-35.....	Both P.....	66 (98.5%)		17 (100%)	27 (90.0%)				3 (10.0%)
1935-36.....	Ad-RP.....								
1936-37.....									
Scott Creek—									
1932-33.....	Ad-RV.....	0	0	0	0	9 (100%)	39 (100%)	4 (100%)	10 (100%)
1933-34.....	Both V.....			1 (1.2%)	0		38 (100%)	79 (98.8%)	177 (97.3%)
1934-35.....	Ad-LV.....	0	0	1 (0.5%)	5 (2.7%)			197 (99.5%)	0
1935-36.....	Ad-RV.....				0			0	6 (100%)
1935-36.....	Ad-AD.....				0				0
1935-36.....	Both V.....				0				

Silver Salmon

Waddell Creek—									
1931.....	Ad-LV.....	17				0			
1932.....									
1933-34.....	Ad-RP.....							4 (16.7%)	27 (21.6%)
1934-35.....	Ad-LP.....	7		20 (83.3%)	98 (78.4%)		Poor records during	4 (21.1%)	0
1935-36.....	Both P.....			15 (78.9%)	0		1933-34		
1936-37.....	Ad-RP.....						and		
Scott Creek—									
1932-33.....	Ad-LV.....	2	0			3	1934-35		
1933-34.....									
1934-35.....									
1935-36.....									

Ad=adipose fin; P=pectoral fin; V=ventral fin; D=dorsal fin; L=left; R=right; Ant=anterior.

From Table 1 it is seen that over a period of four years among the returning steelhead, 233 (97.9%) of the fish marked at Waddell Creek returned to their native stream and only 5 (2.1%) strayed to Scott Creek; and of those marked at Scott Creek, 559 (98.8%) returned to their native stream and only 7 (1.2%) strayed to Waddell Creek.

Among the returning salmon (during the two years for which good records for Scott Creek are available) 133 (79.2%) of the fish marked at Waddell Creek returned to their native stream and 35 (20.8%) strayed to Scott Creek. Salmon have not regularly been marked at Scott Creek, so the amount of straying **from** there for them can not be recorded for the present. Some straying does take place, as shown in Table 1 by the two fish of the 1932-33 Scott Creek marking that were taken at Waddell Creek during the season of 1933-34. However, since the Scott Creek salmon records for 1933-34 and 1934-35 are poor, the three salmon of the 1932-33 marking which returned to Scott Creek in 1933-34 may not represent total returns and consequently homing and straying in this instance are not listed in terms of percentages.

TABLE 2

HOMING AND STRAYING OF TAGGED STEELHEAD TROUT IN SMALL COASTAL STREAMS^a

Year tagged	Returned to Waddell Creek				Returned to Scott Creek			
	1932-33	1933-34	1934-35	1935-36	1932-33	1933-34	1934-35	1935-36
Waddell Creek— 1933-34	Station not operated		3 (100%)	(0)			(0)	(0)
Scott Creek— 1931-32		1(?)—"hole in rt. opercle, prob- ably 1932 Scott Creek tagged fish" (20.0%)	(0)	(0)	83	4 ^b (80.0%)	(0)	(0)
1932-33		1=No. 87932 (4.2%)	(0)	(0)		23 ^c (95.8%)	3 ^d (100%)	(0)
1933-34			(0)	(0)			30 ^e (100%)	(0)

^a None of the tagged fish returning were marked fish.

^b Three of these 4 are included in the 23^c tagged in 1932-33.

^c Three of these 23 are included in the 4^b tagged in 1931-32.

^d All of these 3 are included in the 30^e tagged in 1933-34.

^e Three of these 30 are included in the 3^d tagged in 1932-33.

Table 2 shows the homing and straying of **tagged** fish. Adult steelhead were tagged with individually numbered tags at Scott Creek in 1931-32 (strap tags) and 1932-33 and 1933-34 (disk tags), and at Waddell Creek in 1933-34 (disk tags). At Scott Creek the fish were tagged immediately after being spawned, whereas at Waddell Creek they were tagged before spawning, on their upstream migration. The fact that all fish tagged were adults means that they had all spent one or more years in the ocean. All **returns** on tagged fish, then, are on fish that had made at least two spawning migrations into fresh water and are not directly comparable with returns on fish with clipped fins, which are marked previous to their first trip to the ocean. One difference is that in the case of the tagged fish the parent stream is not known and homing or straying must be considered only in relation to the stream in which tagging took place. Also, the fish tagged being adults, the

returns on these groups are not as large as on the small, marked fish and might alone be inconclusive, especially in view of the possible loss of tags. However, they support fully the results of the marking experiments and are included as supplementary data.

From Table 2 it is seen that, over a period of three years, 60 (96.8%) of the fish tagged at Scott Creek, returned there and only two (3.2%) strayed to Waddell Creek and of those tagged at Waddell Creek three returned there and none were taken at Scott Creek. During 1932-33, 83 fish tagged at Scott Creek in 1931-32 returned there, but since the Waddell Creek station was not yet operating that year the amount of straying can not be recorded and these 83 fish are not included in the above percentages.

The limited degree of straying is emphasized by the fact that no salmon or steelhead marked at Scott or Waddell creeks have been seen at the San Lorenzo Egg-Taking Station since it began operations at the beginning of the 1934-35 season. However, one of the steelhead tagged at Scott Creek in 1931-32 (No. 16088) entered the estuary of the San Lorenzo River during the following year and was caught there in January by an angler. It was a female, 69 centimeters long when tagged and 30 inches (76 cm.) long, weight $9\frac{1}{2}$ pounds, when caught.

Especially in view of the slight amount of straying among the steelhead it is interesting to note one remarkable case of straying and return to parent stream **within the same spawning season**.

The fish in question was hatched at the Big Creek Hatchery during the spring of 1934 and marked by having its adipose and left ventral fins clipped off. It was one of a group of 5608 fish so marked and liberated about one mile below the hatchery, in Scott Creek, on February 11-12, 1935.

Of this group the great majority that returned to spawn returned to their parent stream, Scott Creek. But the fish under discussion strayed to Waddell Creek, and was checked through the dam there on February 5, 1937. A scale sample was taken from the left side and the dorsal fin half-clipped as a temporary mark to show that the fish had been marked and measured at the Waddell Creek dam. It was unusual, but not extraordinary, for this fish to stray to Waddell Creek. But on February 10, five days later, the same fish was found in the tanks at the Scott Creek Egg-Taking Station. The area from which scales had been removed was clearly evident and the half-clipped dorsal fin was conspicuous. Upon examination the scales taken at the time appeared identical with those taken at Waddell Creek. The remarkable feature is that this fish had turned into one creek from the ocean for a distance of one and one-half miles, had then returned to the ocean **without** spawning, proceeded along five miles of coast line to the neighboring stream, and had migrated two miles up that stream, where it was again trapped **within** five days.

Klamath River Experiments

The Scott Creek and Waddell Creek experiments revealed to us the operation of homing and straying in small streams entering the ocean directly. The Klamath River experiments show the operation of these processes within a large river system, the mouth of which flows into the ocean.

The Klamath River, next to the Sacramento-San Joaquin, is the largest and most important of California's rivers. Figure 40 shows the Klamath and its principal tributaries to the Oregon boundary, exclusive of the Trinity River. On this map are shown Copco Dam, an impassable barrier 197 miles above the mouth of the Klamath, and the region below it, including the streams in which marked steelhead were liberated and the egg-taking stations at which they were recovered.

Table 3 shows the various lots of marked trout liberated in Fall and Beaver creeks and the number returning to these streams or entering Bogus and Camp creeks. The "Kosk Creek rainbows" are suspected of possessing nonmigratory tendencies and are not included in



Fig. 40. Map of Klamath River and its principal tributaries to the Oregon boundary, showing streams in which marked steelhead were liberated and recovered.

the main table, especially since scale readings of the returning marked fish of this lot indicated that none of them had descended to the ocean. The fish listed as steelhead are all offspring of races or strains of fish which regularly descend to the ocean. Several other marked steelhead of various sizes returned to their parent stream but are not included in the table, since scale readings indicate that they had not descended to the ocean.

During the seasons of 1934-35, 1935-36, and 1936-37 all of the fish handled in the egg-taking operations at the four above-mentioned stations were examined for marks. These did not include all of the fish entering these streams but did constitute a fair sample. Returning marked sea-run fish for the season of 1936-37 are listed in the table. No **marked sea-run** steelhead were recovered at any of the stations during the two previous seasons.

From Table 3 it is seen that during the 1936-37 season, 45 (100%) of the marked fish liberated in Fall Creek returned there and none were

taken in the other streams. Of the marked fish liberated in Beaver Creek 71 (95.9%) returned there, one (1.4%) strayed to Cottonwood Creek, one (1.4%) to Bogus Creek, and one (1.4%) to Fall Creek.

TABLE 3
HOMING AND STRAYING OF MARKED TROUT WITHIN A RIVER SYSTEM

Steelhead Trout					
Season marked	Mark	Returned to Beaver Creek 1936-37	Returned to Fall Creek 1936-37	Returned to Cottonwood Creek 1936-37	Returned to Bogus Creek 1936-37
Beaver Creek—					
1933-34	Ad-RV	70 (95.9%)	1 (1.4%)	1 (1.4%)	1 (1.4%)
1934-35	Both V				
1935-36	Ad-LV				
Fall Creek—					
1933-34	Ad-LV	0	45 (100%)	0	0
Stream Type Fish (Kosk Creek Rainbow)					
Fall Creek—					
1933-34	Ad-Both V	2	3	0	0

It thus appears that even within a large drainage basin, such as that of the Klamath River, the amount of straying among sea-run steelhead is not much greater than between the small coastal streams, such as Waddell and Scott creeks. That there should be some straying is to be expected, for otherwise the fish could not readily have dispersed and eventually come to occupy all of the streams favorable for their existence.

Conclusions

The answer to the question of whether certain fishes of sporting or commercial importance, such as the steelhead trout and silver salmon, return to their parent stream is one not only of great scientific interest but also of much practical importance. It has a direct bearing on the methods to be employed in maintaining and increasing the runs of these fishes. It is quite apparent that if the amount of straying is as small as these experiments have shown it to be then each stream, so far as the production of a particular species is concerned, must be handled as a separate unit. We can not count on the planting of one stream or tributary to have much effect on the rest.

One of the greatest difficulties which arises in connection with increasing or even maintaining the runs of steelhead trout and silver salmon is the fact that they are not only caught as adults but are also taken by anglers in great numbers as young fish previous to and during their migration to the sea. If such young fish are all caught in any one stream it will certainly mean that within a very few years there will be practically no adults to return to that stream. This applies to both naturally reared and planted fish.

Depletion of the runs of adult fish through the killing of large numbers of young fish is, of course, equally effective whether the young fish be taken by anglers or lost in unscreened irrigation ditches, power turbines, or streams drying up through the diversion of water. Conversely, the loss of adult fish at impassable dams will just as certainly affect the production of young fish.

It is a problem that we must treat at both ends. It is also a problem that we must treat separately in each trout and salmon stream, for the run of fish returning to it is dependent almost entirely upon the number of young fish that are allowed to reach the ocean.

The fact that homing operates within a river system contradicts the theory advanced by Huntsman (1937) that a true homing instinct does not exist and that the fish return to their parent stream only when they do not leave the neighborhood of the river mouth and thus the influence of the fresh water from that stream. It is to be emphasized that in the Klamath River experiments the tributaries in which the marked steelhead were liberated and to which they returned after spending at least a year in the ocean are great distances above the mouth of the river. Beaver Creek is 160 miles above the mouth, Cottonwood Creek 182 miles, Bogus Creek 189 miles, and Fall Creek 196 miles. It is indeed inconceivable that the fish could have felt the influence of their particular small stream during their sojourn in the ocean, 160 to 196 miles or more away, even if they did not leave the neighborhood of the river mouth.

Although proof that steelhead do not in any way have to remain under the influence of the water of their parent stream in order to exercise homing seems to be amply demonstrated in the above situation, it might be added that the mouths of most California trout and salmon streams are closed by sand bars during the summer months and that in some cases the lower courses of the streams are entirely dry, so that no fresh water reaches the ocean.

Just what it is that guides the fish in its return from the ocean to the river system which it left and then into its parent stream is an intriguing problem that has caused much discussion but is still unanswered. Accurate knowledge of movements in the sea, sadly lacking, would certainly be desirable and might shed light on this question. But the fact that homing does exist, though truly remarkable and overwhelming, is by no means surprising in view of its existence among widely separated groups of animals. It operates not only among highly developed vertebrates, such as birds, but also among invertebrates, for example, among mollusks.

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PROGRESS REPORT OF TROUT FEEDING EXPERIMENTS, 1937¹

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Dry plant and animal meals have come into widespread use in this country as fish food wherever the cost of fresh meats is high. There is little question but what a judicious use of meals will produce good growth and health at considerable saving, but there is great variation in the kinds of meals used throughout the country, and too little is known about their comparative value in trout culture. Equally great variation exists in the methods of preparing and feeding meal-meat mixtures. It is the writers' opinion after four years of extensive feeding experiments that preparation and feeding of these mixed foods are equally as important and a much more difficult problem to solve than the choice of ingredients.

Preparation of food for large fingerlings and older fish is not as difficult as preparing meal-meat mixtures for smaller fingerlings. Nevertheless, it offers many obstacles to the producing hatchery and considerable ingenuity is needed to surmount them. The writers wish to acknowledge the help of Mr. Ralph Ledgerwood of the Mt. Shasta Hatchery who has spent a great deal of time during the last two years straightening out the difficult problems which constantly arise in food preparation for the older pond fish.

The cleanest and most economical method of combining meals with meat or using meals alone is to moisten them sufficiently and grind them through an ordinary meat grinder as outlined in last year's progress report.² By this method the food is formed into spaghetti-like strands which can be broken up into "pellets." One requisite for practical pellet manufacture is an electric motor or engine of about five horsepower and a large grinder. An outfit which would be large enough for grinding liver or other fresh meats would not be powerful enough to withstand the greater strain incident to pellet manufacture. Large pellets made through a half-inch plate are much more easily formed and are softer and consequently better for the fish. However, if the trout are not large enough to eat food in such large particles a smaller plate must be employed. When it is necessary to use a quarter-inch plate or smaller, there is great danger of getting the pellets too hard. In fact it is almost impossible to use certain combinations of meals and certain meats in pellets this small. As still smaller pellets are attempted, the choice of ingredients must be even more exacting. To illustrate some of the restrictions discovered in making small pellets we might mention

¹This is the fourth report of experiments which are being conducted at the California Division of Fish and Game Experimental Trout Hatchery located at Mt. Shasta; submitted for publication December, 1937. See also previous reports issued in CALIFORNIA FISH AND GAME: vol. 21, no. 2, pp. 110-124; vol. 22, no. 2, pp. 111-117; vol. 23, no. 2, pp. 138-144.

²Calif. Fish and Game, vol. 23, no. 2, pp. 138-144, 1937.

that lungs make very hard quarter-inch pellets though half-inch pellets with lungs are satisfactory. Liver and fish can be used in the quarter-inch size, and canned sardines being heavy with oil are especially good. The grades of meal are important. Powdered milk makes a much harder pellet than flaked milk. In fact the best combination of meals which we have found for very small pellets ($5/64$ or $1/8$ inch) is about two-thirds salmon egg meal and one-third flaked milk by weight. If it is impossible to make the desired size of pellet with the fresh meal incorporated, it is sometimes advisable to make the pellets of meals alone and feed the meat separately. Thus for young fish, two feeds a day of pellets and one of meat is a satisfactory diet. For adult fish, pellets of straight meal can be fed five times a week and meat twice. One commercial hatchery in the State feeds straight meal pellets five days a week, then lungs one day, and on the seventh day no food is given.

At Mt. Shasta the brown trout brood fish are fed pellets composed of about three-fifths meal and two-fifths fish or meat. The meal mixture is equal parts by weight of salmon carcass meal, dry skim milk and wheat mill run. The fresh fish is spawned-out salmon and condemned canned sardines, and the meats are fluky liver, heart or lungs. The kind of meat used is varied by the market supply.

As we have pointed out, the task of pellet manufacture is filled with difficult problems, especially when the ingredients can not always be the same, nevertheless it should be kept in mind that there is some combination which will work with any ingredients used and by experimentation this desirable combination can be found.

Fingerling Experiments

The principal object of the 1937 set of experiments with trough-reared fingerlings was to determine the minimum percentage of fresh meat for practical hatchery feeding and to determine if possible some practical method of feeding large numbers of small fingerlings on a combination with a high meal content. The senior author also wanted to determine what pathological changes might occur when trout had been fed on dry meals without any fresh meat supplement. Heretofore we have employed about 50 per cent meal and 50 per cent meat in our experimental diets. Most such combinations were satisfactory from a nutritional standpoint but somewhat difficult to feed rapidly enough to make them practical in large hatcheries.

We wanted first to repeat the experiments of numerous workers who have tested the fresh meat requirements of trout and determine the minimum fresh meat percentage which is practical under the conditions of our work. In so doing we felt that the difficulties involved in preparing and feeding such low meat combinations would become evident and a solution might be discovered. However, several unexpected difficulties were presented and the course of our experiments had to be partially altered.

Method

The experimental hatchery located at Mt. Shasta contains 22 regulation California troughs, 16 feet long, 16 inches wide and with an average water depth of 7 inches. The eggs were received in the eyed

stage, hatched in the regulation baskets, and kept in the troughs until the end of the experiments. Records were kept of the daily loss in each trough and of the weights of random samples every two weeks. In so far as possible the care given the fish was similar to that given fingerlings throughout California. Approximately 15 gallons of water a minute entered each pair of troughs, coming in at the top of the upper trough, running through it and falling into the lower trough and so on to the waste pipe. The temperature during the experimental season ran from 36° to 58° F.

Brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and rainbow trout (*Salmo gairdnerii*) were used in the experiments. The brook trout were from Mt. Shasta brood stock (from Vermont selected fish). The eggs averaged 308 per ounce. The brown trout eggs were from Mt. Shasta brood stock and averaged 168 per ounce. The rainbow eggs were from Shackleford Creek, a tributary to the Klamath River, and therefore these fish might better be called steelhead than rainbow as most of the fish caught at this spawning station have been to sea. These eggs averaged 176 per ounce. At the start of the experiments, 23,000 brook and brown fingerlings were placed in each trough, but in the rainbow experiments only 20,000 fingerlings were placed in a trough.

The brook and brown trout started to feed on February 18, 1937, and the rainbow started on May 23. The experiments were continued in the brook and brown until August 24, 1937, and continued in the rainbow until October 1, 1937. Thus the brook and brown trout experiments lasted for approximately six months and the rainbow experiments lasted for five months and one week.

We also had a pond with about three thousand yearling brook trout which we fed an experimental diet of 100 per cent meal. This meal was a commercial balanced dog food, supposedly containing all the elements necessary for health and good growth of dogs. We wished to see if such a diet would be equally healthful for trout. This diet was continued for over six months but the mortality rose in these fish before the end of this time.

Foods

Beef heart was fed to all the experimental groups for the first six weeks. At the end of this time the fish were considered large enough to start on meals and the following diet groups were arranged. The number of fish given for each group represents those which started the feeding trials. Whenever it became evident that the troughs were overcrowded they were thinned down. Thinnings were made as uniformly as possible so that the factor of population density would not affect health and growth to any considerable extent.

1. 46,000 brook and 46,000 brown trout were fed 100 per cent meal for two months. The mortality was so high that the diet was changed to 80 per cent meal and 20 per cent liver for three weeks. The mortality remained high, so 100 per cent liver was fed for two weeks. By this time the fish were improving and were large enough to take pellets, so meal pellets were fed twice a day (65 per cent) and liver once a day (35 per cent) until the end of the experiment.

2. 46,000 brook and 46,000 brown trout were fed 90 per cent meal and 10 per cent liver for eleven weeks. The mortality was then so high that 50 per cent meal and 50 per cent liver were substituted. In two weeks the fish had improved and were large enough for meal pellets, so these were fed twice a day (65 per cent) and liver once a day (35 per cent) until the end of the experiment.
3. 46,000 brook trout were started on a diet composed of 90 per cent commercial dog food meal and 10 per cent liver. This was changed to 50 per cent of the meal and 50 per cent liver, but by the end of sixteen days it became evident that this meal was too coarse and would not stick together well enough to feed small fingerlings. so the diet was changed to 90 per cent sardine meal and dry milk and 10 per cent liver. This was fed for two months. The sardine meal was exhausted, so 50 per cent salmon egg and dry milk and 50 per cent liver were substituted. In two weeks the fish were large enough for pellets so two feeds a day of pellets (65 per cent) and one feed a day (35 per cent) of liver were given until the end of the experiment.
4. 80,000 rainbow trout were fed 75 per cent meal and 25 per cent liver for three weeks, when the oxygen demand from the food pollution plus a decrease in the water supply to about 10 gallons per minute per trough made it necessary to change the food to 100 per cent beef lungs. This was fed to the end of the experiment.
5. 80,000 rainbow trout were fed 50 per cent meal and 50 per cent liver for three weeks, when the same difficulty arose which affected the preceding diet group. The meal was discontinued and 100 per cent beef heart was substituted and fed until the end of the experiment.
6. 80,000 rainbow trout were fed beef heart for six weeks, after which they were given 100 per cent beef liver until the end of the experiment.

At the start, the meal fed most of these fingerlings was composed of dry skim milk and salmon carcass meal in equal proportions. The salmon meal contained bone particles which killed a number of fingerlings and it was necessary to substitute sardine meal which is much more finely ground. This sardine meal, manufactured in California by a vacuum process, was very satisfactory and is perhaps safer than flame-dried meal.

The commercial dog food meal which we tried on the fingerlings and on the yearling brook trout was too coarse for the fingerlings, and as its protein content was low we changed to a balanced mink food meal manufactured by the same company. This has a higher protein content (37 per cent) and we believe that it may find a place in the list of trout foods. It must be supplemented with fresh meat, however.

Summary

Diets of 100 per cent meal (sardine and milk) and 90 per cent meal and 10 per cent liver (by weight) proved to be inadequate when fed to brown and brook trout fingerlings. The trouble undoubtedly lies in the deficiency of the fresh meat factor sometimes called "Factor H."

Fish affected by this lack displayed the following symptoms: emaciation, sluggishness, and loss of appetite; they became dark and often lay on the bottom of the trough although during feeding they rose to the surface and swam listlessly. This last symptom may be aggravated by a decrease in the oxygen attendant to food pollution. Another condition was also displayed by certain fish. These fish appeared large and healthy, but would suddenly dart about entirely without sense of balance and then come to the surface and float motionless, belly up. When removed to a separate trough they would recover in about 75 per cent of the cases, and the remainder would die.

The viscera of the fish which became thin and sluggish showed but one definite and constant abnormality—the kidney tubules were always filled with large hyaline casts. These casts were so conspicuous that they could easily be seen with the medium power of a dissecting microscope. The casts were more apparent in the brook trout than in the brown trout fingerlings. The writers feel that these symptoms characterize an avitaminosis, although this interesting subject should be checked to exclude the possibility that some subtle disease was operating in conjunction with the lack of the fresh meat factor.

There seems little doubt but what 10 per cent liver by weight will not furnish enough of the factor to assure health. When the diets were changed to give 35 per cent liver the results were satisfactory and it seems probable that the minimum level of fresh beef liver in the diet lies around 20 to 25 per cent by weight, as McCay and others have shown.

The principal difficulty encountered in feeding these low meat diets to fingerlings in the producing hatchery lies in the pollution of the water and the resultant oxygen depletion. This was well illustrated in our tests with rainbow fingerlings. We wanted to feed 75 per cent and 50 per cent meal in two diet groups; however, the water temperature was relatively high (56° F.) and the flow of water was unavoidably decreased to 10 gallons per minute in each pair of troughs. The pollution by the meals therefore reduced the oxygen level, which was already low, to the lethal point and the fish were partially suffocated at each of the three feedings a day. As a result the gill filaments became badly swollen and respiration increasingly more difficult. The losses of fish rose alarmingly and we changed the diets to straight meats.

Earlier in the year we had experienced little difficulty in feeding high meal foods to the brook and brown trout fingerlings, but it seems probable that this was due to the water being colder and more plentiful (15 gallons per minute) and because the brook and brown trout are more resistant to low oxygen levels.

Therefore we must conclude that high meal combinations can not be recommended unreservedly until a method is found whereby they can be prepared as efficiently as in pellet form. In the last annual progress report of these experiments³ it was pointed out that pellets can not be prepared for fish smaller than 25 per ounce, and we see that the feeding of fish which are smaller than 25 per ounce presents a very serious problem. In California a large part of our hatchery fish must be liberated while still quite small, and if these fish could be fed com-

³ *Loc. cit.*

binations involving high percentages of meal a very appreciable reduction could be made in the cost of food.

Hatcherymen in the State of Washington ⁴ have used an electric blower to combine meal and liver in a form which is superior to that accomplished by other methods. The present writers have not tried this method, but think that it might be one solution of the problem. Until this method or some other has been tried and found to work successfully, it will be practically impossible to feed trout fingerlings which average smaller than 25 per ounce a meat-meal combination which involves more than 25 per cent meal by weight, and even that percentage must be handled with care.

When the rainbow groups became seriously affected by the meal pollution, the diets were changed to straight beef heart and straight beef lungs, and the third group was left on a diet of straight beef liver. Very little difference was noticeable in the health and growth of the fish given these different meats. It was thought possible that there would be a difference in red cell counts in the blood of fish fed these different meats but averages showed:

<i>Food</i>	<i>Red cells per cubic mm.</i>
Lungs -----	1,346,000
Heart -----	1,300,000
Liver -----	1,122,000

We do not feel that these differences are significant.

Earlier in this paper mention was made of the brook trout yearlings which were fed a straight diet of commercial dog food which was supposedly balanced for dogs. The protein content was low, the carbohydrate content high, and the minerals and vitamins were supposedly sufficient for health, growth and reproduction. This may be adequate for dogs but we wanted to see if the mineral and vitamin content would maintain health in trout. We knew that the low protein content would give little growth. It is probable that these fish obtained an appreciable amount of aquatic and aerial organisms in addition to the food we gave them, otherwise it is doubtful if they would have lived as long as they did. The 100 per cent meal diet was started in January, 1937, and continued for six months, at which time the mortality was so high the food was changed to 100 per cent beef liver for two weeks. The liver caused a rapid decrease in the mortality and added evidence that the loss was from anemia. A blood count was taken for seven fish on March 5 and showed 1,125,000 red cells per cubic millimeter. Another count taken on July 22 showed 508,000 per cubic millimeter. The gills of these fish during the latter stages of the test period were pale and this symptom should be useful in diagnosing anemia. We therefore conclude that a diet containing elements adequate for the health of dogs need not be adequate for trout, and that fresh meat, in this case liver, quickly restores the red count to normal.

Conclusions

1. Brook, brown and rainbow trout fingerlings were used in experiments to determine the minimum proportion of liver which could be used with meals in the producing hatchery. It was shown that about

⁴ Washington Hatcheryman, vol. 1, no. 2, p. 2, 1937.

25 per cent liver by weight is a satisfactory minimum providing that the combination is properly prepared and fed. However, no method was used which proved satisfactory in feeding high meal combinations to fingerlings smaller than 25 per ounce. Fingerlings which are larger than 25 per ounce can be fed straight meal pellets twice a day and meat once a day. Unless some method is found whereby liver and meals can be combined and fed without serious water pollution it will be impractical to feed small fingerlings more than 25 per cent meal with the balance liver. This is an unfortunate situation as the writers feel that a considerable saving of money could be made if it were possible to use about 75 per cent meal plus 25 per cent meat.

2. We also wished to see exactly what took place when fish were fed straight meal or a combination involving very little meat. The symptoms were found to be of two types. In one, the fish lost appetite, became dark, sluggish and emaciated and developed hyaline casts in the kidney tubules, whereas in the second type, large, apparently normal fingerlings would suffer a nervous disorder, lose equilibrium and dash wildly about and then quickly recover in 75 per cent of the cases whereas the remainder died. No gross pathological symptoms were found other than the kidney casts in the first type of disease.

3. At the start of the experiments a salmon carcass meal was used but this contained bone fragments which killed a number of fingerlings. A vacuum dried sardine meal was substituted; this was finely ground and proved to be a valuable fresh meat supplement for fingerlings and undoubtedly for older trout.

4. Beef heart, beef liver and beef lungs were fed as straight diets to three groups of rainbow fingerlings. It was found that there was very little difference in health and growth and that the red cell count remained approximately the same in each.

5. A pond of approximately three thousand yearling brook trout was fed a commercial dog food for six months. This dry meal was fed alone without any fresh meat additions but it is probable that the fish obtained more or less aquatic and aerial organisms. Supposedly this dog food contained all the minerals and vitamins necessary for health and growth of dogs but we found that in about five months the fish became seriously anemic and that by the end of six months the losses were so heavy from anemia that it was necessary to change the diet to beef liver. In about two weeks on 100 per cent liver the mortality ceased.

6. We have verified the findings of previous workers who have shown that fresh meat contains a factor which is necessary to the health and growth of trout.

QUAIL RANGE EXTENSION IN THE SAN BERNARDINO NATIONAL FOREST— PROGRESS REPORT, 1937¹

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INTRODUCTION

The studies made during 1936 and 1937 on a quail range extension project in and adjacent to the San Bernardino National Forest in southern California are presented in this report.

The project, initiated in the summer of 1936, was prompted by the development of a watering device perfected by James Moffit and used successfully by the California Division of Fish and Game within its established quail refuges. The U. S. Forest Service became interested in this device because of the 3,000,000 acres of foothill and woodland areas within the national forests that are either actual or potential quail range and which could perhaps be made more suitable for quail by their use. Many thousands of acres of this area are waterless during the summer and the present studies are aimed at securing and building the factual and biological foundation on which the actual field work of quail range extension, particularly through water development on these waterless areas, might proceed.

During 1937 the work was under the direction of E. E. Horn of the U. S. Biological Survey and under the Division of Wildlife and Range Management of the U. S. Forest Service.

Objective of Quail Range Extension Project

The objective of quail range extension is simply to establish quail on woodland and semidesert lands where they are lacking due to the absence of some environmental factor. A good quail range is assumed to be made of the following constituents:

1. Roosting and loafing types of vegetation (heavily foliated trees or brush at least 10 feet high).
2. Nesting types (usually grasses intermingled with short brush).
3. Food types.
4. Cover or escape types (usually compact brush from 30 to 36 inches high).
5. Water in some form (usually the limiting factor in southern California).

The presence, concentration and interspersion of these factors determine the feasibility of occupancy by quail of any particular range. The absence of roosting, nesting or cover types of vegetation would remove an area from consideration, but there is a possibility of manipu-

¹ Submitted for publication, February, 1938. Published by permission of the United States Forest Service. Photographs by author and Fred W. Johnson of the U. S. Forest Service.

lating the food and water factors. The first is a costly measure but could be accomplished by clearing and seeding with desirable food species. The second, usually the limiting factor in southern California, can be accomplished by placing water tanks on the area. The experiment on the San Bernardino National Forest deals with this factor. It is believed this form of management will produce results well worth the money and effort expended.

In order to determine the biological as well as the economical limitations of quail range extension, the project was started in 1936, in cooperation with the California Division of Fish and Game.

Problems Involved in Quail Range Extension

After careful inspection of numerous areas on or adjacent to the northern boundary of the San Bernardino National Forest, the area selected was chosen because it was typical of much of the higher elevations of our unreserved public domain and the juniper woodland within the national forests. It was known that during the winter and spring, adult quail spread out into this country and usually remain until the green vegetation disappears, at which time the lack of water apparently makes it necessary for them to seek natural springs higher in the mountains. If the quail nest early, the broods survive and also migrate to the mountains. Very likely, if the clutches occur late in the spring, many broods perish. As has been pointed out, general conditions in the study area were not adverse to quail livelihood or development, with the exception of the water factor. Because very young birds can not travel far to water, and since dew, succulent plants and water in any other form are conspicuous by their absence, the matter presented a severe problem.

June to October is the critical drought period. The problem was therefore not only to afford sufficient water on this range during those months but also to obtain proper distribution of water with regard to:

1. Watering the greatest number of birds possible.
2. Spacing the water tanks in such a manner that the young birds would have a continuous water supply in water sources one mile apart.
3. Securing use of all the good quail range.

In placing water on this area, an unnatural factor was established. What would be the effect on the general biotic complex? Rodents such as rabbits, gophers, ground squirrels, desert wood rats, kangaroo rats and white-footed mice were numerous. Would they be attracted to the water sites? Would they compete with quail for food? What would be the vegetative trends on the area under heavy concentration of birds and rodents? The rodents might be greatly beneficial if they act as buffers, thus taking a great load of predation off of the birds. Would predators increase around the water in proportion to the animal life, and what would be the general effect on the quail?

If quail were attracted to the sites, when did use first start? When did the peaks of use occur and when did use cease? Cost studies would necessarily have to be made, and the efficiency of the units improved.

Many of the problems were solved. The solution of the others which were studied will require subsequent observations over a period of years.

DESCRIPTION OF THE PROJECT AREA

History

The history of this area is one of excessive development of marginal farms and their subsequent abandonment. About 1917 much of this public domain was filed upon and many small tracts were cleared in developing the land. Natural soil catchment basins were constructed to water live stock during the summer months. Water for domestic purposes was caught on the roofs and stored in large cisterns. The



Fig. 41. A deserted homestead with remnants of house and orchard. Wild buckwheat is gradually pioneering into the grass and weed zone.

presence of water and more abundant food in the clearings created an environment particularly suited to quail and rabbits. In a few years quail were plentiful. Many of the homesteaders remarked on having seen thousands of quail in large coveys. In many cases, the ranchers in their semi-isolated situation, depended upon quail and rabbits for their meat supply. Some time after 1917, the "bubble" of their agricultural expansion burst and the ranches were abandoned. The fields of grain and alfalfa and the orchards of pears and apples were allowed to return to brush. Through a period of years, all of the houses were either burned or stolen and the orchards taken as firewood. Nothing remains of the original settlement but open cisterns, fire-scarred chimneys or foundations, and an occasional gutted dwelling. (See Fig. 42.)

Many of the property owners still hold the deeds to their land in the hope that oil will be found on the area. Much of the property has reverted to State ownership because of unpaid taxes.

Location, Topography and Climate

The area selected for this study lies on the desert north slopes of the San Bernardino Mountains and on the southern extremity of the Mojave Desert at an average elevation of 4,000 feet. The topography is considerably broken, especially adjacent to the mountains, by long, shallow, dry canyons and flat narrow mesas. The country flattens out three miles from the mountains into a gently sloping topography, drain-



Fig. 42. A deserted ranch site. The cistern and a few remnants of the house are all that remain of a \$7,000 investment.

ing toward the desert and the Mojave River. Moisture in the form of dew and water is present only during winter and spring. The mountain range creates a definite barrier for the storms coming from the Pacific Ocean, and differences in rainfall, within a few miles, range from five to twenty-five inches annually. Rains seldom occur more than once a month during the rainy season and usually are of short duration. During the summer and the dry part of the year, the temperature varies from 65 to 110 degrees F., usually averaging about 95 degrees. Low humidities ranging from five to thirty-five per cent prevail. Wells have been drilled on the area to a depth of 600 to 800 feet before water was

found. Only one spring is to be found on the range. This comes from an old mining tunnel half a mile from our watering site No. 6. The only natural water is found in a series of springs lying along a fault approximately five to seven miles from any of the sites. Many species of food plants, such as lupine, trefoil, four-o'clock, mustard and filaree, remain green and succulent until the latter part of July.



Fig. 43. Typical view of study area, showing roosting type of vegetation in foreground and food type in distance.

Vegetation

Two life zones are represented on the area. The Upper Sonoran is found close to the mountains and the climax vegetation is mesa oak (*Quercus dumosa*), chamise (*Adenostoma fasciculatum*) and manzanita (*Arctostaphylos*). This type breaks suddenly into the Lower Sonoran Zone, with the climax vegetation composed of juniper (*Juniperus californica*), sagebrush (*Artemisia*) and Joshua trees (*Yucca brevifolia*). Food types (weeds and grasses) are present, but the quail carrying capacity of these areas as to food supply is yet to be determined.

As soon as the range was homesteaded, the plow and fire broke up the climax cover into an excellent interspersed of heavy brush, light brush and clearings. These clearings are now in a successional stage



Fig. 44. Typical quail roosting area of juniper, interspersed with Joshua trees, wild buckwheat, trefoil and sagebrush.



Fig. 45. Watering site No. 10, showing the observation blind in left foreground.

and are gradually reverting to the climax type. The cover on these openings at the present time is characterized by trefoil (*Lotus*), lupine (*Lupinus*), filaree (*Erodium*), mustard (*Brassica*), California buckwheat (*Eriogonum*), wild plum (*Prunus*), sumac (*Rhus*), annual brome grasses (*Bromus*), and various other kinds of grasses. Most of these are excellent food species for quail. The irregular and spotty nature of these areas now affords quail edgings, food and nesting types. Roosting, escape and loafing cover are to be found in the adjacent climax types. The whole range is in a zone of tension between the Lower and Upper Sonoran life zones. As erosion affords no problem, it appears there is a place for clearing in creating additional food types. Sagebrush, wild buckwheat, grass and some perennial leguminous plants will establish themselves readily.

USE AND INSTALLATION OF WATER TANKS IN QUAIL RANGE EXTENSION

Description and Installation of Water Tanks

In August, 1936, R. M. Tullar was assigned the task of installing water tanks in known waterless areas where quail ranged during the early part of the year, but were absent during the dry periods.

By September, 1936, seven sites had been established. Because of the lateness of the season all were not filled with water, and no detailed records of use were kept. At least two of the sites had use. Site No. 6, even at that late date, was visited twice daily by 45 mountain quail. On June 10, 1937, five additional sites were located and all tanks were filled and were operating.

At each site, 8 to 10 feet from the water, a blind was carefully constructed of light wood, burlap sack and brush. From this vantage point, photographs were taken of birds, quail, rodents and snakes using the water.



Fig. 46. Water site No. 8; water trough at right, observation blind at left.

Hawk traps were placed on posts at several of the sites to obtain a measure of the hawks and owls that were attracted to the sites.

The cost of installation of the standard trough unit (see Fig. 47) included \$2.50 or less for materials and two man-days of labor.

The labor and material costs for the "dew-dropper unit" (see Fig. 49) were both considerably less.

The maintenance of these units required but little time. The troughs were cleaned out from time to time or were lowered or raised as their condition warranted. In our case, the hauling of water to make the refills required the greatest amount of time and energy. If a tank truck could have been used it would have taken but a day and a half to fill the tanks at all 12 sites.

For the most part, the apparatus used by the Forest Service was similar to that used by the California Division of Fish and Game in their quail refuges. A slight modification was devised in 1936 by R. M. Tullar to suit our conditions. The apparatus used in the first installation differs from the others, mainly in the fact that it was fence-enclosed to exclude live stock. In subsequent installations a simple cover was devised over the watering trough to protect it from cattle. (See Fig. 47.) The cover is more efficient than the fence since it also discourages use by coyotes. Coyotes and dogs, however, by thrusting their muzzles sideways through the iron rods, were occasionally able to obtain water.

In general, the apparatus consisted of:

- a 50-gallon drum (12-gauge)
- $\frac{3}{8}$ -inch pipe connecting the drum to the trough
- 2 unions (to facilitate moving)
- 1 trough (24-gauge galvanized iron)
- 2 redwood planks, 2 x 8 x 24 inches
- 20 iron bolts

A constant water level is maintained in the trough by making use of "negative pressure" in the drums (in principle like the watering apparatus used in chicken pens).

With regard to the operation of the units, several points should be mentioned. The drums are made air-tight by the use of leather washers and some petroleum water seal. The copper tube acts as an air feed; as water flows from the drum into the trough, air must enter into the drum through the tube. When the water in the trough reaches a depth of $2\frac{1}{2}$ inches, it is level with the end of the copper tube in the drum, and this level is then hydrostatically maintained. The water level in the trough can easily be altered by merely lowering or raising the trough. The air-tight chamber of the trough is formed by two incomplete partitions which just cut the water's edge. In the front partition, the remaining space is filled by a strip of window screen to prevent any trash from getting back into the cleaning chambers and thence clogging the pipe. The back partition is left incomplete so that, from time to time, both chambers may be cleaned of any fungus or dead insects that may be present by removing the lid and reaching in.

The placing of sharp-pointed staples in the trough to prevent lapping animals from drinking is a waste of time and hinders adequate

cleansing of the screen. These staples in no way discourage dogs from obtaining water.

The trough is set in cement. Within the cement and extending into the ground for a depth of ten inches to a foot, is a continuous strip of chicken wire to prevent rodents from undermining the trough and destroying the level. Into this cement are set twenty 8-inch bolts to

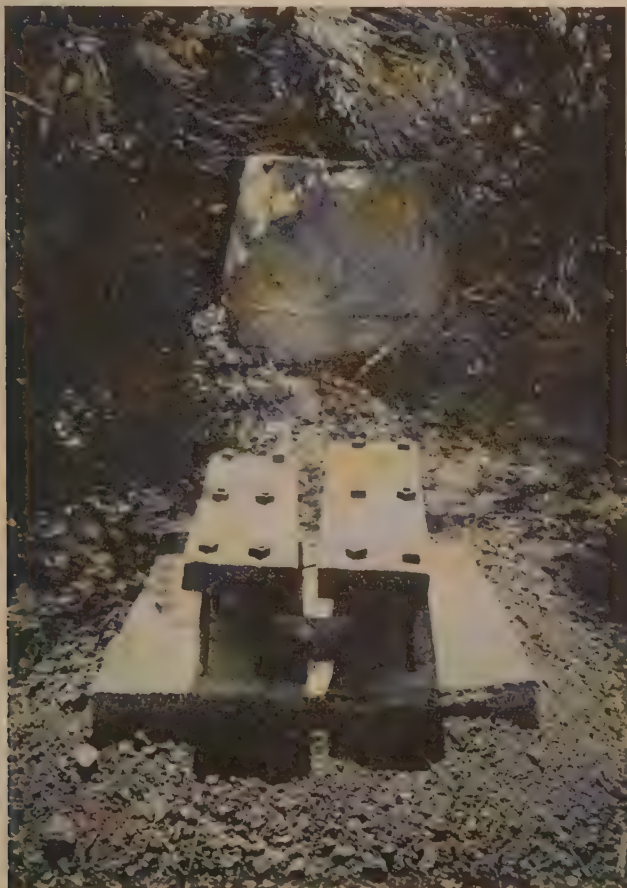


Fig. 47. Standard quail watering unit; tank in background, trough set in concrete with wooden protector to keep cattle out.

support the cover, this consisting of two separate boards 2 x 8 x 24 inches. The distance between the top of the trough and the bottom of the cover is 5 inches. The two halves of the cover are not placed farther than $1\frac{1}{2}$ inches from each other, and parallel. The $\frac{3}{8}$ -inch pipe is buried, mainly to prevent trampling and to prevent disturbance of the set-up, were the pipe to be jarred.

The following precautions should be exercised in manipulating this equipment:

1. In setting up or removing, be especially careful when screwing the pipe into (or out of) the soldered bushings.



Fig. 48. Quail watering trough used by California Division of Fish and Game. This open type should be enclosed by a fence in cattle country.

2. In refilling the drum, always first screw on the refill cap in the trough, otherwise, when the refill bung is removed, all the water will flow out of the drum and trough.

3. Always be certain that the drum is absolutely airtight except for the copper tube.

4. When picking a spot to place the drum, either place it in solid shade and encase in an insulation of dirt, or if the slope is sufficient, completely bury the drum. If this is not done, expansion from temperature fluctuations may be sufficient to cause the trough to overflow. Fluctuation of the water in the trough is in direct proportion to the temperature and in indirect proportion to the amount of water in the drum.

A radically different watering unit was used at one of the sites, and to date has proven very successful. (See Fig. 49.) It merely consists of a single pipe leading out of the drum and into which are screwed small brass "alemite-like nipples" approximately one foot apart. The small ball-like valve is bright and the quail readily peck at it, obtaining a few drops of water each time. A small drop of water usually is suspended there and the sunlight glinting on this drop also serves to attract the birds. According to Sumner² quail frequently satisfy their water requirements by utilizing small dew drops found on vegetation. A small tin trough is placed beneath the nipples to

² Sumner, E. Lowell. A life history study of the California quail, with recommendations for conservation and management. CALIFORNIA FISH AND GAME, vol. 21, no. 3-4, pp. 167-256, 277-342, 1935.

catch any waste drip. There is always a small amount of water in the trough and the birds drink partly from the unit and partly from the trough.

Individual quail develop their own technique for using the nipples. Many quail hold their open bills against the valve and drink without moving their heads; others will seize the valves vigorously each time. The majority turn their heads sideways and merely peck lightly at the bright brass valves, obtaining a drop or two at a time.

This unit apparently has many advantages:

1. Efficient means of dispensing water.
2. Other animals can not manipulate the valves.
3. Quail readily learn to manipulate the valves.
4. Drum need not be air-tight.
5. No insulation required.
6. Inexpensive installation (approximately 20 cents per foot of pipe).
7. Minimum evaporation because there is no exposed water surface.



Fig. 49. Mountain quail drinking at the "dew dropper" unit—one from nipple and one from trough.

There is a possibility that dirt in the water would cause the valves to remain open and allow the water to escape. This has never hap-

pened to this particular unit. Highly mineralized water might cause a precipitate to form around the valves, not allowing them to seat themselves evenly. This could be remedied by cleaning off the valves with sandpaper at the beginning of each summer season.

An important factor to remember when installing this unit is to keep the water pressure as low as possible. High pressures are conducive to wastefulness—when a bird trips the valve, water will shoot out under high pressure conditions.

As previously mentioned, the extreme fluctuation of the length of exposed water surface in the trough was a continual source of water waste. This was caused by the expansion of air within the drum. If the trough were adjusted to adequately supply the quail with water during early morning and late evening, by mid-day the trough would overflow. If adjusted during mid-day, no water would be exposed in the early mornings when the birds usually watered. An attempt was made to reduce this daily fluctuation by insulating two drums with dirt. This resulted in a reduction of almost 70 per cent in the daily fluctuations.

Factors Influencing the Supply of Water in Tanks

The following study concerns the loss of water from the 50-gallon tanks through evaporation, use by animal life, and overflow of trough due to high temperatures.

TABLE 1
AVERAGE AMOUNT OF WATER LOST THROUGH EVAPORATION

Film length (inches)	Average number cubic centimeters evaporated per day (24 hrs.)	Average number of gallons evaporated per month
2	90	0.7
4	162	1.3
6	174	1.37
8	133*	1.0
10	180	1.4
12	240	1.9

* Taken under high humidity conditions.

TABLE 2
DATA TO BE USED IN ACCOUNTING FOR WATER UTILIZATION PER MONTH

1. Amount of water evaporated per month (average of 6 levels).....	1.3 gallons
2. Use per quail per month (3 waterings daily).....	0.237 gallon
3. Bees (large apiary) per month.....	43.0 gallons
4. Birds, rodents and overflow.....	Great

From tables 1 and 2, one can account fairly accurately for the water utilization at any particular site. It is difficult to say exactly how much water will be used at any one site, for they all have varying intensities of use by bees, rodents and birds. Some tanks have a large daily fluctuation in film lengths and will overflow during extremely high temperatures; several gallons of water may be lost daily during a severe heat wave.

The two-inch level is the distance which loses the least water through evaporation; there is but a slight difference in loss between the 4-inch and 10-inch levels. At any rate, if the troughs are kept filled,

we can expect to lose little over two gallons per month through evaporation.

Water Requirements of Quail

Until some effort is made to tag or mark the birds, it is difficult to determine the exact water requirements of quail. In numerous controlled experiments, it was found that mountain quail utilized between 9.5 and 10 cubic centimeters at a watering, with an average of about 9.8 cubic centimeters. There appears to be no established number of watering periods during the day. The habits of the coveys are vastly different and even the coveys themselves are very inconsistent. If it is warm and dry, they will visit the water two and three times daily. If moisture in the form of dew is available they are likely to water only once every two or three days. At times they will be at the water at the break of day or in the evenings when it is too dark to see them. Again, they will visit the sites at mid-day and remain for several hours around the tank, drinking, loafing, and dusting.

Table 3 and the following data indicate the amount of water required by each site from June 10 to December 1, 1937, ten days less than six months. The drums were all filled or nearly so at the conclusion of the experiment.

TABLE 3
WATER USED AT EACH SITE JUNE 10-DECEMBER 1, 1937

Site No.	Amount of water (gallons)	Remarks
1	182	Medium use by quail; heavy bird use
2	123.5	Very light use by quail; heavy bird use
3	188	Very light quail use; heavy bee use
4	280	No quail use; heavy bee use
5	146.5	Medium quail and rodent use
6	188	Very heavy quail use (dew dropper)
7	194	Medium quail use; bees
8	193	Early, heavy quail use
		Later, light quail use. Bees and rodents
9	188	Early, heavy quail use
		Later, no quail, heavy bird and rodent use
10	211	No quail use; heavy bee use
11	171	Heavy quail use
12	270	Very heavy quail use
Total..	2335.0	

Data pertinent to utilization:

- Period of use..... Approximately six months
- Average amount of water required by all 12 sites..... 194.6 gallons
- Most representative site under constant use by quail alone..... Site 6, which used 188 gallons
- Average amount of water required per month per site..... 32.6 gallons
- Average length of time one tank would last..... 1.4 months
- Maximum used by any site..... Site 4: 280 gallons. No quail use; many bees
- Minimum used by any site..... Site 2: 123 gallons. Very few quail; many birds; insulated to allow a constant short film of exposed water.
- Range between maximum and minimum..... 156 gallons
- Two sites most efficient at any time during the summer..... Site 2: average 9 gallons per month during last 3 months. Little or no quail use; many birds
Site 6: average 15 gallons per month under use by 50 to 75 quail. (Dew dropper)
- Most inefficient sites at any time during the summer..... Site 10: used 45 gallons per month when apiary operating; no use by quail
Site 4: used 45 gallons per month; no quail use; large apiary present
- Heavy use by 50 quail..... Used about 12 gallons per month

THE EFFECT OF WATER DEVELOPMENT

The Quail of the Study Area

Three species of quail are found in the San Bernardino National Forest. The most abundant species in the study area is the mountain quail (*Oreortyx picta plumifera*), which comprises 74 per cent of all



Fig. 50. Gambel (desert) quail, adults and fledglings, drinking at site No. 9.

the quail at present. Next in abundance (23 per cent) is the valley quail (*Lophortyx californica vallicola*). Desert or Gambel quail (*L. gambeli*) are rather scarce, composing but 3 per cent of the quail population.

The mountain quail thrive mainly in the Transition Zone, but not abundantly. Odd as it may seem, these birds were the ones found on the range in the largest numbers, and consequently were the ones observed in this study. The desert environment is not adversely suited to their welfare, for they are frequently found near water in the dry, barren hills east of Victorville and Barstow, 40 to 100 miles into the Mojave Desert. These birds do not seemingly stand up well under present hunting regulations, and their presence in the San Bernardino Mountains can be attributed to the dense brush in which they are usually to be found during the hunting season. They are great rangers and can readily be attracted long distances if the various factors conducive to their welfare can be found. The water tanks proved to be very attractive to mountain quail.

The desert quail ranges for the most part outside of the forest boundary, except perhaps in the vicinity of Palm Springs. Many of these birds are found in Coachella Valley and around Barstow where they are found preponderantly in the mesquite association. It is

entirely possible that these birds are not dependent upon water in its physical state but can use that found in succulent plants to just as efficient advantage. However, during the course of this study, they were actually seen and photographed at one of the watering sites. (See Fig. 50.)

Biota in General and Its Relationship to Quail

California jays are abundant and there is a possibility that they are important as regards quail egg destruction. No evidence was found that they are detrimental. They drink considerably at the sites, but are timid around the quail. The quail fledglings react rapidly to the alarm calls of the ever vigilant jays. Many times broods at the water troughs were observed to scurry to cover at the jays' wild screeches, to be well hidden when a hawk approached.

Horned larks, thrashers, thrushes, sparrows, flickers and doves all are present in moderate to abundant numbers. They visit the sites and drink several times daily and are only important in that they utilize and waste water. The thrashers, sparrows and jays bathe continuously, and frequently the ground is wet for a distance of two feet on all sides of the trough as a result of their ablutions. All of these birds are apparently timid and respect the stolid mountain quail.



Fig. 51. Sparrows drinking and bathing at site No. 1. This is an uncovered trough, protected from cattle by a fence.

Sharp-shinned and Cooper's hawks are fairly abundant on the study area. These two hawks are definitely predators of quail, but it is difficult to determine to what extent. In four cases they were seen to kill quail at the watering sites. Several were caught in the hawk traps.

Horned owls are plentiful on the range and probably take some quail. Five were caught in the hawk traps. On examining the pellets from these birds, we found no evidence that quail had been taken; only the remains of wood rats, kangaroo rats, rabbits and small snakes were found.

The tracks of skunks were never seen, and bobcats are apparently scarce. There are about two coyotes to the section, and they frequently



Fig. 52. Part of a covey of mountain quail watering at site No. 8. Note how the birds are crowded around the trough.

visit the water troughs. I do not believe that they are of any great importance as quail predators, as indicated by stomach and scat examinations. These coyotes are great rangers as grapes were frequently found in the feces and there are no vineyards or grapes closer than seven miles from the range. Their diet consisted almost entirely of rabbits and other rodents.

Deer are frequently seen in the area during the winter months. Live stock occupation is seldom and slight.

Rodents are numerous and consist mainly of rabbits, gophers, California ground squirrels (scarce), antelope ground squirrels, desert wood rats, kangaroo rats and white-footed mice. These animals are competitors with quail for food, and if attracted to the sites, might create complications. A measure of the rodent concentration was made by running two transects of traps across one of the sites before water was installed. The initial study showed no trends, *i.e.*, rodents were not particularly more abundant near the sites than at a distance. On October 4-7, 1937, the height of the drought period, another sample was made, and still no trends were in evidence. (See Table 4.) Another trapping should be made in June, 1938, which would be comparable to the initial survey.

TABLE 4

NUMBER OF RODENTS CAUGHT (INCLUDING TRAPS SPRUNG OR LOST) AT WATER SITE No. 8 BEFORE AND AFTER WATER WAS AVAILABLE

Distance from water (feet)	June 11-19, 1937, before water was available	October 4-7, 1937, after water was available
5	1	7
20	3	4
35	1	1
50	3	2
65	3	3
80	2	3
95	4	0
110	3	1
125	2	3
140	0	4
155	2	5
170	0	0
185	3	1
200	1	3
215	4	1
230	2	0
245	1	3
260	4	2
275	2	1
290	3	4
305	4	1
320	2	1
335	2	2
350	2	6
365	1	1
380	3	6
395	0	1
410	3	2
425	4	1
440	2	2
455	4	-
Totals	71	71

It is quite possible that water, in its physical state, has no attraction for these desert rodents. They may obtain sufficient moisture from the taproots of desert plants or by a chemical breakdown of the carbohydrates. Of the diurnal rodents, ground squirrels (both antelope and California) drink frequently. Numerous photographs have been taken of several of them drinking at the same time. There is a possibility that these rodents are important as regards clutch destruction; valuable information could be obtained by making a study during the nesting cycle.

Rattlesnakes, racers and other snakes are attracted to the water. They have been observed drinking on numerous occasions. The stomach contents, when examined, never disclosed quail or their eggs; rabbits were found frequently.



Fig. 53. A cleared mesa with filaree, trefoil and mustard. An old homestead.

Study of Vegetation by Quadrats and Transects

In order to measure vegetative trends around the sites, quadrats were established and should be re-observed from year to year. This study was carried on at site No. 8. Meter-square quadrats were placed at different distances on four axes, 25 and 200 feet on the north, 135 and 386 feet on the west, etc.; six of this type were located. Two stakes were driven into the corners of each quadrat to facilitate realigning the plots when the examination is again made; distances and compass bearings were also taken. The vegetation upon each quadrat was charted to a scale of 16 square inches to a square meter. Plant colonies were mapped to scale and an appropriate letter abbreviation of the species placed within the area. Symbols were used for isolated and individual species. Too often there is a tendency to adopt methods of obtaining such information from established practices, such as grazing. At times, in this work, the methods should be altered to garner the desired results. The effect of quail and rodent utilization can not be compared with that of deer or cattle. For this reason another method was adopted in which random sampling was sacrificed. Milacre quadrats were established in belts parallel to and extending out from the water troughs. One belt was 20 feet from the water, another 80 to 100 feet. Care was exercised to place these plots in food types (filaree, mustard, etc.) and in areas of similar species and densities.

Two quadrats were placed in the burned area west of sites Nos. 1 and 2. This fire occurred in a climax type of oak and manzanita. It is hoped that the quadrats will aid in determining the successional trends of vegetation after burning. It is possible that spot burning, to create an interspersed of food and cover types, has a place in quail management. From casual observation of the hills north of the railroad, repeated small fires have improved this area for quail range.

In order to gain a better understanding of the area as a whole, a 3000-foot transect was made across a typical portion of the range. Three photographs made along this transect (Figs. 43, 53 and 54) give a better idea of the topography and interspersed of plant types than a written description.

GENERAL OBSERVATIONS ON THE QUAIL RANGE

On or about June 1, 1937, actual work started on the range. Pairs of quail were frequently seen; approximately 25 pair were spotted, but more could have been found if a detailed survey had been made. All available time was utilized in installing the water sites as rapidly as possible. Several coveys were located at this time, the fledglings being from two to six weeks of age, indicating that some broods had hatched in April. The nesting sites were well distributed over the range; it



Fig. 54. East end of line transect; deserted ranch and feed type of vegetation in foreground, brushy mesa in background.

did not appear as though the presence of the previously installed water sites had influenced the locations of the nests. Fog, dew and succulent vegetation were present, and water in its physical state was evidently not essential.

The cocks were heard daily, uttering their calls from the tops of the junipers. They were not, in all cases, unmated males. Frequently

upon approaching them; nesting hens were flushed nearby. This habit of the rocks continued until after the broods were hatched. Several small coveys of fledglings were located by following the calls of the males. No utilization of the water sites took place until the fledglings were well feathered out and able to fly short distances. The success of the clutches was markedly good; many broods were in evidence, and all contained from 12 to 15 fledglings, which is quite high.

The use of the respective units is indicated in table 5. The peak



Fig. 55. Mountain quail watering at site No. 8. Note the chipmunk at left of trough.

of use occurred from August 1 to September 1, and closely corresponds to the high temperatures and the disappearance of the succulent vegetation. The continuation of use so long past midsummer was probably caused by the long dry fall which was characterized by infrequent light rains and frequent dry north winds.

The tabulation of water utilization presents several problems which are difficult to answer unless a trapping and banding study should be made, together with a life history study of the mountain quail on this area. Apparently the usual habit for these quail was to spread over

the area during the winter and spring, nest, and return to the mountains when drought conditions became critical on the desert. This casual migration was partially halted by the installation of water, but some migrations continued. Site No. 10 was spotted in an isolated locality because of the presence of one pair of mated quail. During the course of the summer many coveys ranged across this site toward the east and southeast and did not visit the water. This area was thoroughly searched for nests or mated birds, and with the exception of the one pair, none was found. Evidently these coveys were making their annual pilgrimage to the mountains or the Mojave River. Site No. 10 was not desirably situated; an apiary was located close by and the trough was always literally swarmed over by bees. From other observations, we know that the quail are nervous and jumpy around the bees and are often reluctant to drink in their presence. This trough received but one visit during the summer, but quail tracks were usually found within 20 to 50 feet of the water.

The fact that some sites received immediate regular visits by quail, and others only periodic visits months later, is another problem. Possibly crop analyses taken at definite times would reveal the answer. At Site No. 5 quail were always seen around the site, but they did not start to use water until a month or six weeks after several of the other sites. At sites Nos. 8 and 9, the first heavily used units, the visits ceased altogether by September. There could have been several answers for this action. Predators might have depleted the coveys, a migration might have taken place after flocking, or they might have moved to other sites. The last explanation would explain the observed increase at other sites.

The survival of the fledglings was exceptionally good until they were three-quarters grown. At that time, the coveys began to be severely depleted. At sites Nos. 5, 7, 9 and 12, I found evidence where sharp-shinned and Cooper's hawks had taken the quail while they were watering. It appears that the greatest danger from predators occurs with mountain quail when the birds are almost mature. Evidently they do not react as quickly to the alarm calls of the parent birds; they are larger and afford better targets for hawks; they are more careless and wander from the covey. This predation occurred in the space of a month. In some cases, only 4 or 5 birds remained out of an original covey of 15. It is believed that toward the end of the summer many of the larger coveys were really flocks composed of the remnants of smaller coveys.

Daily observations and photographs were made from the blinds adjacent to the water sites, and much was learned about the habits and reactions of mountain quail. The maximum number of quail using the sites was approximately 637, with an average for the whole summer of about 313. The intensity of use corresponded closely with weather conditions. During rainy or cloudy periods, they would water irregularly, every day or two. Otherwise the frequency of their visits probably was controlled in many cases by the interspersing of the various habitat factors. It was noted that where all the factors, food, cover, roosting sites and water, were compactly distributed, the coveys ranged very little, not often exceeding one-half mile. At site No. 6, which was located a mile or more from the feeding grounds, the quail ranged considerably. I have observed them covering this distance in rapid time because of their eagerness to reach the water. Valley quail also ranged consider-

TABLE 5
WATER UTILIZATION BY QUAIL, JUNE 10, 1937-JANUARY 30, 1938

Site No.	June 10	June 15- June 30	July 1- July 15	July 15- July 30	Aug. 1- Aug. 15	Aug. 15- Aug. 30	Sept. 1- Sept. 15	Sept. 16- Oct. 31	Nov. 1- Dec. 1	Dec. 1- Dec. 15	Dec. 15- Jan. 1	Jan. 1- Jan. 15
1.....	0	0	Regular 2 coveys (30-40)	Regular 3 coveys (40-50)	Regular 3 coveys (40-50)	Regular (25-30)	Periodic (20-25)	Periodic (10-15)	Periodic (40-50)	Periodic (40-50)	0	0
2.....	0	Periodic *1 covey	0	0	Regular 1-2 coveys (15-20)	Periodic (15-20)	0	Periodic (25-30)	0	0	0	0
3.....	0	0	0	0	*Periodic 1-2 coveys (15-20)	Periodic (15-20)	0	0	1 visit (25-30)	0	0	0
4.....	0	0	0	*Periodic 1 covey (12-15)	Periodic 1 covey (12-15)	Periodic 1 covey (12-15)	0	0	0	0	0	0
5.....	0	0	0	*Periodic 2 coveys (25-30)	Regular 2 coveys (25-30)	Regular 2 coveys (12-15)	Regular (3-12)	Regular (3-12)	0	0	0	0
6.....	0	0	*Regular 4 coveys (50-60)	Regular 4 coveys (50-60)	Regular many coveys (150)	Regular (150)	Regular (150)	Regular (50-75)	Regular (50-75)	Periodic (25-30)	Periodic (25-30)	0
7.....	0	*Periodic 1 covey (10-12)	Periodic 1 covey (10-12)	Periodic 1 covey (10-12)	Regular 2 coveys (25-30)	Regular (20-25)	Regular (35-40)	Regular (12-15)	Periodic (25-30)	Periodic (25-30)	0	0
8.....	0	*Periodic 3 coveys (25-30)	Regular 2 coveys (25-30)	Regular 3 coveys (35-45)	Regular 3 coveys (35-45)	Regular 3 coveys (25-30)	Periodic (45-50)	Regular (15-20)	0	0	0	0
9.....	0	*Regular 2 coveys (25-30)	Regular 2 coveys (25-30)	Regular 3-4 coveys (35-45)	Regular 3 coveys (35-45)	Periodic (15-20)	0	0	0	0	0	0

10	0	0	0	0	*Watered once, 1 covey (10)	0	0	0	0	0	0	0
11	0	0	*Periodic 2 coveys (15-25)	Regular 3 coveys (30-45)	Regular (25-30)	Regular (35-40)	Regular (35-40)	Periodic (25)	Periodic (35-40)	Periodic (25)	Periodic (25)	0
12	0	*Periodic 1 covey (8-10)	Regular 3 coveys (35-40)	Regular many coveys (75-200)	Regular (75-200)	Regular (75-200)	Regular (75-150) Some dew and fog	Periodic (35-75)	Regular (75-150)	Periodic (30)	Periodic (30)	0

* Indicates—First use.
 Covey—Family (hen, cock, fledglings).
 Number—Number in covey.
 Periodic—Irrregular visits (3 to 4 days apart).
 Regular—Daily or twice daily visits.
 Sites 1, 2, 3, 4, 6, 11, 12 installed in 1936.
 Sites 5, 7, 8, 9, 10 installed in 1937.

ably if these various factors were widely distributed, but they tended to remain more in the same locality. No observations were made on the desert quail because of their scarcity.

The watering habits of the three species are essentially different. The mountain quail are more stolid; observations and photographs were easily made. The Gambel and valley quail are very alert, especially the Gambel. Often a slight movement by the observer or the click of the camera shutter would frighten the whole covey.

Mountain quail are great loafers and spend considerable time dusting, playing and pluming themselves in the shade of the junipers or



Fig. 56. Mountain quail at the "dew dropper" unit, site No. 6.

manzanitas. If they water in the early mornings, they remain at the site from 20 to 45 minutes. If they visit the site during the heat of the day, they are likely to remain from two to four hours. They drink periodically during this time, but the majority of the covey would be found loafing and dusting.

The parent birds are ever alert for danger, and have definite positions for guarding while the fledglings are watering. In two coveys that were carefully observed, the cock and hen always took definite positions. The cock, in one covey, always mounted the wooden covering of the water trough. The cock in the other covey always first circled the entire site and took his position on a small hillock 25 feet from the

trough and in the open. In many cases, the adults did not drink until the fledglings had finished and frequently, during the first of the summer, never touched the water. During the course of a twenty-minute drinking period, the fledglings would scurry to the adjacent protective brush cover several times; this was always done at the warning calls of the parents or blue jays. For this reason the water should always be located under some protective brush cover.

Many roosting sites were found, and in only one case was a mountain quail found roosting on the ground. This bird was injured and unable to follow his mates, spending the night at one of the sites and on the ground. Coveys were found roosting in manzanitas, mesa oaks and junipers. The birds perch on the limbs about 16 inches apart. A few birds were observed near the top and bottom, but the majority were near the center of the crown. On one occasion a covey spent the night on the wooden rails of a fence that enclosed one of the sites, completely exposed to owls and other night predators.

These quail rarely or never drank immediately after leaving their roosting sites in the mornings. As soon as it began to get light, a few birds would fly to the ground, ruffling their feathers and stretching their legs and wings; soon they were followed by the others. They would immediately start feeding in a sort of "skirmish line" formation and in the general direction of the water site. The lateness of their watering on the previous night apparently determined the time of morning that they drank. They seldom used the same roosting site twice, but would invariably approach the watering sites from the same direction. After watering, they would feed considerably around the site and would frequently return to drink two or three times. They scratch and feed in the patches of filaree and lotus, but will continue moving even though they range into an area where food is scarce. They may cross the food patch several times, but do not tend to linger and satisfy their hunger in any one place.

During the hunting season, the hunting effort was observed in different types of cover of varying densities. It was interesting to note that on areas with cover of a density similar to the project area, limits of valley quail were scarce. This species will survive well if the cover affords half a chance to escape. Adjacent to the range, several limits of mountain quail were checked. The hunters claimed that once the coveys were located, they encountered no difficulties in getting a limit of birds. Mountain quail shooting in our heavy brush areas, the typical mountain quail country, was poor. The quail were present but the dense brush restricted hunting.

A survey of the area, the reaction of landowners to the study, and whether or not to close the study area to hunting presented serious problems and considerable thought was given to the subject. Two alternatives presented themselves at the beginning of this study:

1. Should the area remain open to hunting to determine how well the quail could increase under open shooting conditions?
2. Should the area be closed to hunting to facilitate the study of quail under natural conditions—then, when the range was adequately stocked (two or three years), close only small areas around the watering sites?

The latter alternative was adopted. It was then necessary to survey and map the area and accurately locate each site, tying it into

the Public Land Office survey. This done, the ownership was determined from the tax records and each property owner was contacted and requested to sign temporary agreements, allowing us to close their property to hunting and permit us to make the study.

The majority of the landowners were sympathetic and signed the agreements. A few persons were opposed to signing their names to any agreement, fearing some hidden clause. They did not object to the study or the closure but were afraid of tying up their property.

In any extensive quail range extension project on these desert lands, the attitude of the owners of deserted homesteads is the most important single factor. They are holding the land for speculation, oil or otherwise, and the best meant explanations and agreements are useless against their stubborn refusal to sign their names to any agreement unless some monetary remuneration is offered.

CONCLUSIONS

It was expected that the installation of water on our desert range would attract valley quail; instead, about 75 per cent of the birds using the water troughs were mountain quail. In any area where the brush cover is such that the hunters consider it "good hunting country," it is believed that the mountain quail will not stand up under even medium shooting. They are large, slow moving targets and have such strong terrestrial instincts that they are difficult to flush. They will stand stupidly around and be shot on the ground. On this forest, it is believed, they owe their present survival to the exceptionally heavy brush stands where they are to be found during the hunting season. If valley quail can not be attracted to the area, an experiment in artificial planting is recommended. If and when the area is opened to hunting, the brunt of the shooting should not be borne by the mountain quail. The extension of mountain quail range is not recommended.

This study is not complete, and the accomplishments to date should be taken as a progress report. The objective—attracting and holding quail on this waterless area through the use of water tanks—has been successful. The total effects of a study as intricate and far reaching as this can not be started and completed within a few short months. The natural environment of this area has been disturbed by the introduction of a foreign factor, water. Natural trends and changes occur slowly; it may be years before the actual effects can be observed. However, the preliminary studies show that quail range extension is feasible and that the biological consequences would not be detrimental. Continued observation over a period of years should be made. The opportunity for stocking with desert and valley quail is excellent. Increases in population could be made together with the determination of population levels in this type of country.

The hunting areas in the more populated sections of southern California are becoming limited. More hunting clubs, private property and "no hunting" signs, are seen yearly; the sportsmen will soon demand more public hunting areas. In our Public Domain and desert wastelands lies the solution to the problem. Thousands of acres of this land lie unproductive and idle, ready to be changed from a wasteland and scenic curiosity to a valuable shooting ground.

THE MUSKRAT AS NATIVE AND ALIEN: A CHAPTER IN THE HISTORY OF ANIMAL ACCLIMATIZATION ¹

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The muskrat (*Ondatra zibethica*) is one of the characteristic and conspicuous rodents of North America. Its native range includes a large part of this continent. From the early days of settlement down to the present day the muskrat has occupied a position of major economic importance in the fur trade. Its wide geographic range, its abundance numerically and the ease with which it may be trapped have resulted in the taking of millions of pelts. Records from Canada indicated an annual take from 1919 to 1924 of between two and three million annually. The number of muskrat pelts used by American furriers in 1919 was estimated to be over eight million. Despite this heavy and continued levy, the muskrat, unlike the beaver and some of the carnivores, has maintained its range and general population level, largely because of its fecundity. During recent years, interest in fur farming has resulted in the escape and transplantation of the muskrat in many areas where it was not native, in western North America and in various parts of Europe and Asia. In time the muskrat will probably be the most widely distributed single species of fur-bearing mammal in the world. Its spread in western Europe during the past 30 years constitutes the most outstanding instance of successful acclimatization among wild mammals in the present century.

Over most of its native range the muskrat is considered an asset, by reason of its value as a fur-bearer, with few or no detrimental aspects. Such is the case in many of the marshy areas of the eastern United States and in Canada.

In regions where canals are necessary for irrigation or for drainage, muskrats, when present, constitute an adverse factor since their burrows may lead to breaks in the banks of such canals.

Original Distribution

Under primitive conditions the muskrat occupied the greater part of Canada and the United States. It was and is more generally distributed in the East and North, while in the arid West its distribution is discontinuous by reason of the localization of marshes and other suitable habitat. The species is lacking from certain seemingly favorable areas in the Southeastern and Gulf states. Muskrats probably reached some of the now isolated waters of the West during a period

¹Contribution from the Division of Zoology, College of Agriculture, University of California, Davis, California. Reprinted (with some changes by the author) from *Journal of Mammalogy*, vol. 18, pp. 443-460, 1937.

when aquatic and palustrine habitats were more widespread, in late Pleistocene or postglacial times. With subsequent contraction of habitat, stocks were reduced and isolated, since when limited subspecific differentiation has occurred. Parallel cases are known among amphibians and fishes in the western states.

In California the muskrat was native only to the Colorado River, along the Arizona boundary, and in scattered localities affording suitable habitat on the arid east side of the Sierra Nevada, from northern Mono County to central Lassen County. It was not present in the interior (Sacramento and San Joaquin) valleys, nor in the Modoc plateau. Newberry (1857, p. 62) was the first observer to comment on the suitability of these areas and their lack of occupancy by muskrats.

Some of these gaps in the original distribution of the muskrat are puzzling, since the species occurs in essentially similar habitats but a short distance away. Thus, in northeastern California the native occurrence at Eagle Lake, in Lassen County (of subspecies *mergens*), is less than 50 miles from suitable territory on Pit River in Modoc County. Parts of the Pit River drainage, as detailed beyond (Fall River Valley, Shasta County), have since proved eminently suitable. If muskrats had, in times past, reached the Pit River in northeastern California, they could very well have reached the Sacramento-San Joaquin basin, as they bid fair to do in the near future. Such gaps in distribution, where a species should occur "logically," only reflect our imperfect knowledge of the factors controlling animal distribution and emphasize the importance of the study of transplanted stocks.

Transplantation

Transplantation of animals to new localities has been a feature of man's activities since before the dawn of recorded history. The dogs of the American Indians, several domesticated animals, and the rabbit and pheasant in parts of western Europe, are early instances of transplantation and acclimatization. Transfer of the muskrat to new localities began, so far as available records indicate, after 1900. The first conspicuous transplant was that into Bohemia in 1905. One instance in California apparently dates back at least to 1911. A majority of the records, however, are more recent, following the development of fur farming. Interest in the possibility of farming muskrats probably arose from emphasis on the general decline in stocks of wild, fur-bearing animals, the success in the artificial rearing of silver foxes, and the development of the American fur markets following the World War. During the decade 1900-1910, little was said, in the literature, regarding depletion of the wild fur supply. Attention was focussed on the subject during the next decade, when numerous articles and books stressed the ever increasing market for fur, the decline in wild stocks, and the possibilities of fur farming as a means of augmenting the supply. At the beginning of the century, owners of a few marshlands in eastern states had already recognized the value of the muskrats thereon, and such areas were treated as preserves, or "wild farms," from which a regular annual yield was obtained. In 1917, Lantz stated that the commercial value of muskrat skins individually was so low as not to warrant attempts at purely artificial production. Despite this and other similar statements, there developed, subsequent to 1920, a

large popular interest in the possibilities of breeding muskrats under various artificial conditions. The matter, being new, was subject to little or no legal regulation. Interest in the capture, production, and sale of "breeding stock" increased. Fur journals carried advertisements of allegedly fancy breeding stock, offered at obviously fancy prices. The history of this endeavor has not been written fully and the extent to which wild stock of various subspecies was mixed is unknown. One farm in California was reported to have obtained stock from Colorado, North Dakota and Ohio, thus possibly involving at least two subspecies; Alaska and Quebec muskrats are stated to have been crossed, and other admixtures are hinted, but whether these attempted hybridizations were successful is unknown. In several instances the original animals or their descendants have escaped or have been liberated in various localities. Whether "dealers" trapped their "selected breeding stock" from local marshes or obtained it by purchase or exchange from other dealers is unknown. Little of a definite nature can be said concerning the muskrats now abroad in some localities, and future monographers of the genus may be puzzled by specimens from such areas. Inferences on subspecific differentiation in nature must depend on such material as was available to Hollister in 1911. For a few transplants the exact source is known; those that survive will show whether or not such introduced stocks will respond to new environmental conditions by change in characters.

A complete record of muskrat transplantations probably can never be written, since continued inquiry brings reports of a multiplicity of introductions and transplants. The stock in Germany, Austria and Czechoslovakia is presumed to have descended from not more than two small introductions. If such actually be the case, it constitutes a record of successful acclimatization unequalled, as to smallness of original stock, by the alien rats of seaports, the European rabbit in Australia and New Zealand, or by the European house sparrow in North America. Furthermore, the results of the European transplant should serve, as do some other alien transplants, thoroughly to discount the theory of decline by inbreeding so dear to the minds of many sportsmen.

Transplant and Spread in Europe

Details of the introduction and spread of muskrats in continental Europe are available to American readers in part through a recent article by Mohr (1933). A voluminous literature already is in print on the subject in Germany, clues to which may be gained from the article just mentioned, and from the books by Toldt (1929) and Ulbrich (1930). Several papers² provide information for England, France, Germany and Scotland.

For many details regarding muskrats in Europe I am indebted to officials in charge of rodent control operations in the several countries here discussed. Through conversations in 1934, by literature supplied then and subsequently, and by answer to later inquiries, I was aided by Mr. E. C. Read in the Ministry of Agriculture and Fisheries at London; Mr. T. Munro and Mr. Hyslop, Scottish Department of

² See literature cited at end of this paper: Chappellier (1930, 1933); Hinton (1933); Pustet (1928, 1933, 1936); Munro (1931, 1935); Warwick (1934), and others.

Agriculture in Edinburgh; Dr. Martin Schwartz, Biologische Reichsanstalt für Land- und Forstwirtschaft, Berlin-Dahlem; Dr. A. Pustet, Bayerische Landesanstalt für Pflanzenbau und Pflanzenschutz, Munich; and Dr. A. Chappellier, Service des Vertébrés, Centre Nationale de Recherches Agronomiques, Versailles. Mr. M. A. C. Hinton of the British Museum (Natural History) aided my studies in England.

Beginning at Dobruška, about 25 miles southwest of Prague, Bohemia, in the spring or autumn of 1905, a few (2.5 to 10) pairs of muskrats from Canada were released. From this center the species has

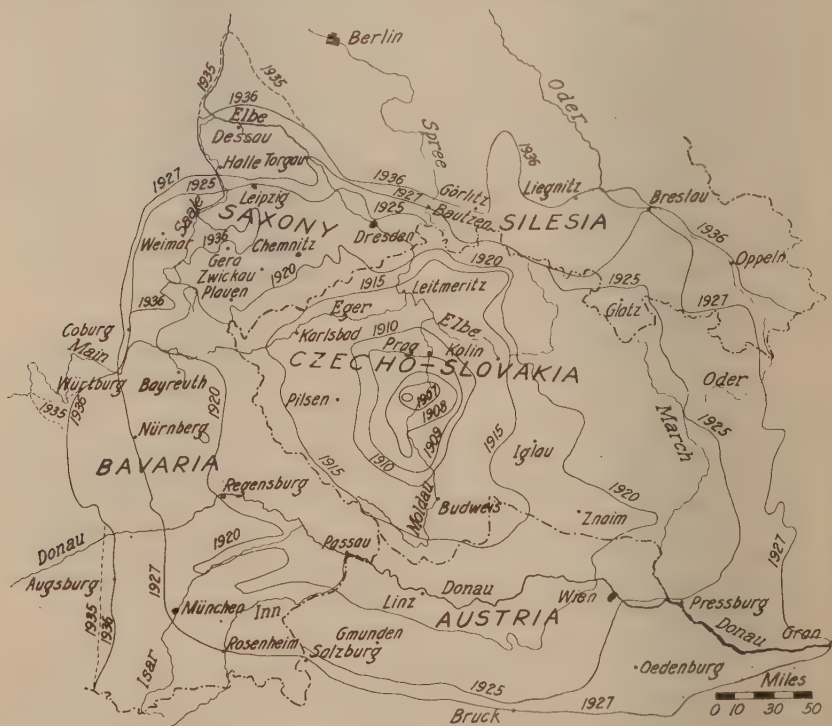


Fig. 57. Spread of the muskrat in central Europe. Original introduction in 1905, southwest of Prague in Bohemia (now Czechoslovakia). Areas occupied in succeeding years are outlined. Regions freed of muskrats in 1935-36 in western Bavaria and Saxony surrounded by dotted lines. Adapted from Ulbrich (1930) and Pustet (1936).

spread in ever-widening range, like the ripples from a pebble thrown into a pond, until now this alien rodent occupies an enormous territory covering Czechoslovakia, much of Germany (fig. 57), Belgium, Holland, and parts of Austria and Poland. Muskrats have been captured on at least one occasion in Switzerland and a center, from a separate source, has been established in eastern France near Belfort.

Under the more rigid economic limits of life and sustenance for people in central Europe, the interpolation of any new element arouses concern. As early as 1912, attention was directed to the potentialities

of the muskrat for harm. The countries of western Europe with much rainfall have extensive drainage systems to dispose of excess water. The principal damage by muskrats involves burrowing in canal banks, railroad fills and earthen dams. Culture of carp and other fish in ponds is an established industry in Germany, and muskrats have damaged such ponds and caused holding dams to break with consequent loss of water and fish. In a few instances they are reported actually to have eaten carp.

Germany

The entrance of the muskrat into Germany was a natural consequence of the spread from Bohemia. There are no sharp biological barriers and the waterways crossing international boundaries afforded every opportunity for spread of muskrats. Ulbrich's (1930) chart shows clearly that the increase of territory occupied was a natural spread. By the time control measures were instituted in Bavaria the species already occupied a wide extent of waterways. The work in Bavaria (1917) was, so far as I can ascertain, the first major attempt at control, and time was lost in development of suitable methods and administrative procedures. In addition, publicity was needed to arouse the interest of farmers and other people on the land regarding the potentialities of the muskrat. It seems evident, from perusal of the German literature of the period, that no hope was held of being able actually to exterminate the muskrat, but early in the work a defense line (Sperlinie) was established (München, Regensburg, Nürnberg, Bamberg, Lichtenfels) along which it was hoped that trappers might resist advance to the west. Despite considerable expenditures (for example 34,671 RM or about \$8,668 in 1927) this proved impossible, and muskrats spread beyond the line. The world-wide economic depression reacted unfavorably on the control program by decreasing the funds available in subsequent years for payment of trapping premiums and employment of trappers, while interest on the part of private trappers declined with reduction in pelt values. In 1927 muskrat pelts brought the trappers 5 to 7 RM (\$1.25 to \$1.75) each, while in 1929 this declined to a figure as low as 1 RM, rising then to 2 or 3 RM. In 1934, when I visited Munich, work was still in progress, at a cost of from 30,000 to 35,000 RM annually (A. Pustet, personal communication, March 20, 1934). Meanwhile, interest in the spread of the muskrat through Germany continues, and each year there appears in an issue of the "Nachrichtenblatt für den Deutschen Pflanzenschutzdienst," issued at Berlin-Dahlem by the Biologische Reichsanstalt für Land- und Forstwirtschaft, an article summarizing the yearly change. This information is kept down to date on a spot map in the Biologische Reichsanstalt. Each year's article includes a map of the current distributional situation and notations regarding new records of muskrats in the various states of the Reich. It is my impression that the agricultural officials are now reconciled to the continued presence of the animal and that future effort will endeavor to hold the numbers down by official trapping and by continued stimulation of public interest. It now seems impossible that the countries of central Europe can ever hope actually to rid their lands of the muskrat. The species will not

only hold much of the territory already occupied, but may continue to spread and, in time, to occupy most of continental Europe suitable for its existence.

When interest was aroused in Germany over the possibility of damage by muskrats to earthworks, numerous state and local governments passed laws placing the animal in the nuisance category and making conventional stipulations regarding notification of presence and control by landholders. Many of these are reprinted by Ulbrich (1930).

In Bavaria, Prussia and Thuringia, trappers have been paid by the State; in Saxony the hunters have been under State license and were paid only bounties but were allowed to sell the pelts taken for their own account. Bounties there in 1934 were 30 to 50 pfennigs per animal, and more where muskrats were scarce. Trappers wear a distinctive armband. Officials have to guard against trappers leaving small "nuclei" of muskrats for future breeding. A total of 137

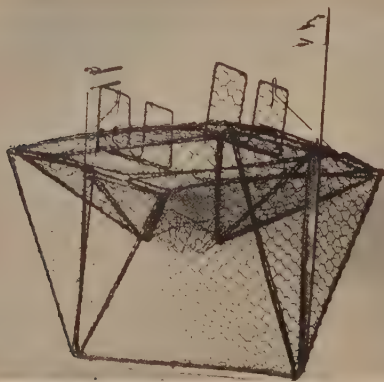


Fig. 58. A collapsible wire-screen trap to be set in the water on the route of swimming muskrats; used in Germany.

licensed trappers was operating in Saxony during 1934. The annual damage in the Reich was estimated at 70,000 RM, these costs being borne by the Ministries of Agriculture, Railways and Public Works (Ernahrung [incl. Landwirtschaft], Eisenbahn und Verkehr) because railroads, embankments, road structures, bridges and waterways all are state-owned. Many

applications were made earlier, especially by small landholders, for permission to establish muskrat farms, but these were refused and the law now provides penalties for keeping muskrats in captivity. Entry of muskrats through customs now is prohibited by law, but due to ignorance of the species by customs inspectors, difficulties are experienced in enforcement; muskrats have, at times, even been declared as rabbits or guinea pigs. Control operations in Germany were conducted by the individual states until 1935, but in that year operations were consolidated for the Reich and Dr. A. Pustet, earlier in charge of work in Bavaria, undertook direction of the general program (M. Schwartz, letter, March 17, 1937).

In Bohemia, muskrats are believed to have reached an equilibrium as to numbers. The animals do less damage to waterways there, since many of the structures are reinforced with stone. In Germany, many waterways are earth-lined; hence greater damage is possible (M. Schwartz, April 13, 1934).

Other Continental Countries

Muskrats have appeared in other countries of Europe, including Austria and Hungary. In France, muskrats escaped from a farm near Belfort and in the Department of Ardennes (A. Chappellier, January 15, 1934). In 1937, the territories of Belfort and Bas-Rhin were occupied; trapping had been employed to hold the animals in check and experiments with virus were being conducted (A. Chappellier, letter, March 15, 1937).

The species has been introduced into Finland in Kronoby near Wasa (1922), and in Ylivieska and Tuulois (1923). This is a region of many lakes. The annual spread of 30 to 40 km. has been aided by trappers and already a number of pelts have been taken. Thus far the benefits outweigh the damage (Mohr, 1933, p. 62).

In Poland, muskrats first appeared during the winter of 1929-1930 in Oberschlesien, in the Kreissen of Rybnik, Teschen, and Pless. By 1933 they were in Wojewodschaff Kielec, in former Russian Poland. First efforts at control were made in 1932, and in that year a law was passed against human aid in spreading muskrats, with a fine of 2000 zlotys or 6 weeks imprisonment. (Dr. Christiana in *Nachrichtenblatt für den Deutschen Pflanzenschutzdienst*, vol. 13, p. 108, 1933.)

There is one report of a few muskrats having been taken in Switzerland on or near Vierwaldstätter See, but no statement of further occurrence has been noted for that country. There has been a serious invasion in Belgium (C. Elton, letter, February 8, 1938; Mayné, 1935).

In 1934 van Poeteren indicated that the Netherlands were then concerned over the potentialities for harm by this rodent to the all important dikes and dams of their country. The species was then only 58 miles away, and has since "arrived" in Holland (C. Elton, letter, February 8, 1938; Kluyver).

Muskrats have been introduced into several places in Russia, but full details as to the current status of the species in that country are not available. Eyerdam (1932, p. 281) reported a shipment of muskrats from Ontario, Canada, to Petropavlovsk, Kamchatka, in 1928. Lavrov (1933a) states³ that muskrats were introduced "in the Solovietzkiy and Karaghinskiy Islands, in the Kol'skiy Peninsula, near Archangel and Volodga, in the Ural Province, West Siberia, and the Yakut, A. S. S. R." A total of roughly 486 was imported, 1928-31, from Canada and Finland. In another paper (1933b) Lavrov mentions visiting muskrat farms at Solovietzsk, Slobodsk and Kostroma and says that in 1930 "the rodent was set free in many northern regions." Some of the animals were confined in cages for study of food habits while others were in fenced enclosures. By the end of 1932 the population had grown to "several thousands."

British Isles

In the British Isles, muskrats were introduced into Scotland in 1927, and into England in May and June, 1929, at Shoeburyness, Essex. But an even earlier introduction is reported at Great Missenden, Buckinghamshire. In Ireland, muskrats were imported to County Tipperary

³Details of the work in Russia with muskrats have been made available to me through translations of Lavrov's articles by Mr. M. Dobrynin of the WPA translation bureau in the University of California at Berkeley.

in July, 1927. Early in 1930, M. A. C. Hinton and E. C. Read had 76 records (including some unconfirmed reports) of places where muskrats were or had been kept. At first, according to Mr. Read, certain government officials considered that muskrat farming constituted a



Fig. 59. Cage trap with "door" of individual wires at right; set at mouth of burrow to catch muskrats driven out by probing in the bank; used in Shropshire, England.

new and useful industry meriting encouragement. Soon, however, this viewpoint was reversed, due to the escape and rapid spread of the rodents, coupled with adverse opinions by Messrs. Hinton and Read and other mammalogists conversant with the potentialities of the muskrat for harm, as hitherto demonstrated in Germany. On March 17, 1932, the Destructive Imported Animals Act was passed by Par-

liament. This placed the importation and keeping of muskrats under control of the Minister of Agriculture and Fisheries in England and the Secretary of State for Scotland. A Statutory Rule and Order (No. 153) promulgated by these officials, effective May 1, 1932, in England, Wales

and Scotland, provided for licensing of muskrat owners and conferred on officials the right to destroy muskrats found at large. Penalties were provided for noncompliance, and owners as of June 24, 1931, who were refused licenses, were given permission to apply for compensation for loss of investment. Only 14 licenses were issued. In March, 1933, an order effective April



Fig. 60. Floating trap set at margin of quiet stream; the floats are metal tubes sealed at the ends; used in Surrey, England.

1, 1933, prohibited absolutely the importation or keeping of live muskrats in Great Britain. Similar laws were passed for the Isle of Man and by the Irish Free State (E. C. Read, May, 1934; Warwick, 1934, p. 251).

Warwick (1934) had record of 76 places in England, one on Isle of Man, 10 in Scotland, and one in Irish Free State where muskrats had been kept. Animals escaped from 12 of these and centers of infestation developed in five localities, namely: Shrawardine, Shropshire; Farnham, Surrey; Pulborough, Sussex, England; Feddal, Perthshire, Scotland; and Nenagh, County Tipperary, Irish Free State.

Governmental control campaigns were instituted in 1932 and 1933 in all these places. Field crews were organized, Herr Roith, the highly successful Bavarian trapper, was "borrowed" to demonstrate field techniques, and a thorough-going program looking toward actual elimination was instituted. In England, the crews were equipped with motor trucks capable of carrying a boat, and general reliance was placed upon trapping. The Roith technique ("Stöberfang"), involving use of a probe inserted from above ground on the bank containing a burrow, with wire catching cage at the burrow mouth, was used in part. A special type of burrow-entrance trap was developed (fig. 59). In addition, two ingenious types of floating traps were developed, use of which was chiefly to indicate presence of muskrats rather than as a means of extermination (fig. 60).

In England, prior to 1932, an estimated 1500 muskrats were taken by private individuals. The official campaign there resulted in the capture of muskrats as follows:

	<i>Shropshire (Salop)</i>	<i>Pulborough, Sussex</i>	<i>Farnham, Surrey</i>
1932-----	1,531	---	---
1933-----	1,064	144	39
1934-----	181	8	12
1935-----	7	1	1
1936-----	1	0	0
Totals-----	2,784	153	52

The annual costs (financial year ending March 31) were:

1932-33-----	£2,913	
1933-34-----	£6,519	
1934-35-----	£4,200	(estimated)
1935-36-----	£2,750	
1936-37-----	£1,050	(£100 recoverable by sale of equipment)
Total-----	£17,332	[= \$84,580]

Each muskrat taken cost \$28.29. The campaign was terminated on March 31, 1937 (E. C. Read, letter, March 17, 1937).

Similarly, the control of muskrats in Scotland involved:

<i>Expenditures</i>		<i>Muskrats Taken</i>
1932-33-----	£840	51
1933-34-----	2,600	764
1934-35-----	2,900	154
1935-36-----	2,240	7
1936-37-----	1,100	2
1937-38-----	200	---
	£9,880 [= \$48,610.80]	978

Each muskrat taken, therefore, cost \$52.43. The Scottish campaign was to be closed before June 30, 1937 (T. M. Munro, letter, April 14, 1937).

The campaign in Scotland showed some of the problems involved in efforts actually to rid an area of a pest; the area was small and subjected to careful scrutiny, so the numerical details probably are quite accurate. Governmental operations began in October, 1932. During 1933, the staff of trappers was increased from 4 to 13 and a supervisor, remaining thus through 1934. The animals taken were:

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
1933	14	47	72	51	51	57	40	78	135	104	62	53	764
1934	27	19	13	11	17	19	9	5	10	4	13	4	154

Early in 1933 there were not sufficient trappers to control natural increase; as the staff increased and became more efficient, the population was far reduced. Only three family groups were taken in the latter half of 1934; all others were stragglers. In 1933, rats were taken in 38 squares of the Ordinance Map; in 1934, in only 23 squares. Yet at the end of 1934 it was considered that rats might occur anywhere within an area of 400 square miles. With decrease in physical labor of trapping, fewer men were employed, but need for even more careful scrutiny and inspection increased. Motorcycles were provided to aid this phase of the campaign (Anonymous, *Scottish Jour. Agric.*, vol. 18, pp. 175-178, 1935).

The difficulties involved in a final clean-up were illustrated in an artificial pond, Loch-an-Erie, at Gleneagles Golf Course. In March, 1933, Herr Roith, the Bavarian trapper, saw a burrow there, but trapping produced no results. This burrow was watched and in August, 1934, evidence of occupancy was noted; again trapping was unfruitful. There was no sign in late October. A flood then occurred on River Earn, after which the loch froze over. On November 8, another trapper saw bubbles beneath the ice, indicative of muskrats. Five muskrats were subsequently caught in the loch (Munro, 1935, p. 12). Whether the pond was continuously occupied or reoccupied with the flood was not known.

The need for continued scrutiny of old burrows is obvious. Control workers in England preferred not to collapse such burrows but to leave them; fresh occupancy by rats missed earlier could then be detected more readily. When muskrats obtain food from under water and eat or store it in deep burrows, or when they feed at a distance from the burrow, detection is difficult.

During the campaign in Scotland a considerable variety of other animals was taken in the trapping operations, including (up to September 29, 1934) 1745 brown [Norway] rats, 2305 water voles, 57 weasels, 36 stoats, 2178 moorhens, 113 ducks, and miscellaneous other birds such as 23 seagulls, 13 each of curlews and redshanks, 28 snipes, 15 European blackbirds, and one eel—a total of 6587 animals, including both harmful and beneficial species (Munro, 1935, pp. 11-16).

For the Irish Free State, exact details are not available, but "several hundreds" of muskrats have been taken (E. C. Read, letter, March 17, 1937).

Current Status in Europe

In summary, according to information now in hand, it seems entirely probable that muskrats have been or will be entirely exterminated in England and Scotland. Success, if attained, will be due to the relatively small areas involved, to the nature of the terrain, to the adequate financial support of the government, and to the industry and persistence of the personnel involved. In continental Europe, the muskrat probably will remain as an acclimatized alien of dual importance, useful as a fur bearer but harmful in varying degree to earthworks, water channels and fish ponds. A review of the efforts to date in Germany shows that earlier, despite earnest endeavor with moderate financial support, spread of the species beyond the Sperlinie established in Bavaria had not been checked. Under concerted action in 1936, however, slight reductions were made in extent of territory occupied (Pustet, 1936).

Transplants in North America

Turning to North America, details as to spread of the muskrat by the aid of man are available for British Columbia and for California.

British Columbia

Muskrats were native to the mainland of British Columbia but not on Vancouver Island. In 1923, small numbers were liberated on the Island in the Cowichan Lake district by the Provincial Game Commission. Their status in subsequent years was briefly as follows: 1925—increasing; 1926—also in Somenos Lake and sign on Saanich Peninsula; 1927—increasing; 1928—also near Port Renfrew; 1929—several reports of muskrat damage to crops and lands in Cowichan and Saanich districts; 1930—increasing rapidly, many damage complaints, special trapping permits issued to farmers; 1931—catch of muskrats on Vancouver Island about 9000 pelts; 1932—on increase, many permits to farmers during closed season; 1934—many taken for fur, farm complaints lessened; 1935—few farm complaints and fewer taken by fur trappers. (Summarized from Reports of Provincial Game Warden, later Provincial Game Commission, 1923-1935, inclusive.)

It is also reported that muskrats were planted at Miller Creek, Forbes Landing, close to Campbell River, 6 in 1923 and 6 in 1924. Creeks and swamps south of this locality subsequently became well populated and crop damage due to muskrats was reported in 1931 (Ronald M. Stewart, B. C. Police, Atlin, letter, December 4, 1931). In 1933 they were reported north to Comox and also as introduced on Denman Island (T. Pearse, Courtney, June, 1933).

Muskrats were also planted on Graham Island, in the Queen Charlotte Islands, in 1924 or 1925, near New Massett and probably elsewhere. In 1933, at a site fully 30 miles from the place of introduction, a muskrat made nightly visits to catch fry of pink salmon at an experimental counting screen. Dikes in Tlell River, erected to hold back salt water, were reported to have been damaged (Pritchard, 1934, p. 103).

California

The first important translocation of muskrats in California followed as a natural consequence of building (1901) the International Canal carrying water from the Colorado River to the then desert Imperial Valley. While earlier there may have been occasional muskrats in the region (cf. Mearns' observations in 1894), the construction of more

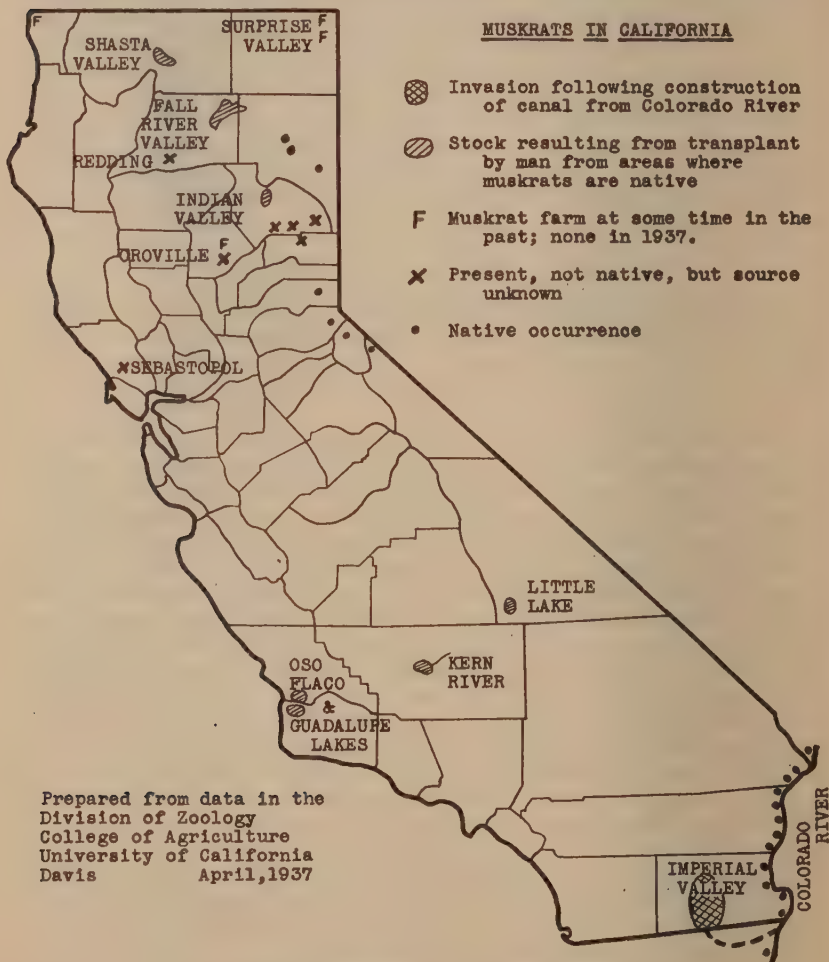


Fig. 61. Muskrats in California, 1937

than 300 miles of mainline canals and numerous small ditches, with subsequent inevitable growth of aquatic vegetation, provided an admirable extension of habitat for this species. The first were noted about 1905. E. A. Goldman saw many holes in irrigation banks in June, 1907, and in 1915 L. J. Goldman said damage had been caused and the irrigation district was paying bounties of 50 cents to \$1.00 per

head. In 1921, Joseph Dixon studied the muskrats in the valley and obtained reports of 20 to 40, and exceptionally 200, muskrats per mile of canal. He concluded that the pocket gophers, which had also increased, were responsible for more damage, by burrowing in canal banks, than the muskrats (Dixon, 1922). Nevertheless, the officials of the Imperial Valley Irrigation District considered that muskrats caused damage by burrowing in banks between adjacent parallel canals and around headgates (where wire mesh had to be inserted to check burrowing and the gnawing of wooden gates). From 1925 to 1932 the district paid \$33,204.50 in bounties on 139,012 muskrat tails at 12.5 cents (to mid-1927), later 25 cents each. Some unrecorded bounties had been paid earlier. The system was abandoned in 1932 because of financial difficulties. One break in the canal system cost \$5000 to repair (MS data from District Manager, 1935). Under favorable conditions of fur prices, as in 1919-1920, Dixon figured that 25,000 muskrats (estimated to be half the local population) were taken annually in the valley at \$1.25 per pelt, yielding \$31,000; this would amount to far more than the damage (Dixon, 1922). Damaged structures, however, must be repaired at the expense of the district, whereas income from muskrat furs accrues to private trappers. Furthermore, private trappers have less incentive to work during seasons of low prices, and always prefer to trap where animals are abundant rather than in critical areas where smaller numbers of the rodents may be causing damage. Replacements in the population are rapid, breeding being reported in Imperial Valley for every month in the year, but especially from about February 15 to October 30, with possibly 3 broods averaging 6 (3 to 9) each.

As previously mentioned, under original conditions in California, muskrats occurred only on the east side of the Sierra Nevada in scattered localities, and in the Colorado River. Transplantation or escape of captives has now resulted in establishment of muskrats in several places west of the mountains. Some of these localities are so isolated from other drainage basins that there is little likelihood of the animals radiating and establishing new centers; other colonies are on tributaries of the Sacramento-San Joaquin drainage system. The known transplants in California are:

Colorado River at Needles, San Bernardino County.—William Pugh reports that he introduced 75 muskrats (subspecies unknown) purchased from dealers in Oregon, Montana and Ohio, in 1930 to 1933. These were darker animals, planted in the hope that they would hybridize with the local *pallidus* (= *bernardi*) and result in pelts of higher fur value (E. R. Hall, Mus. Vert. Zool. field notes, February 1, 1934).

Kern River and Buena Vista Lake, Kern County.—Muskrats, presumably of subspecies *mergens*, were introduced in 1911 or earlier. The actual date, source and means are unknown. The population increased and considerable numbers are reported as taken for fur; later control measures were used against the animals. In the winter of 1936-1937, it was stated that few or none were left; the lake had been dry for several years and irrigation canals at Bakersfield, formerly occupied, had been dry for a long period. Later in 1937 the lake was partially filled with water.

Guadalupe and Oso Flaco lakes (west of Santa Maria, Santa Barbara County).—W. N. Morrison in 1927 introduced 149 individuals of the race *pallidus* (= *bernardi*) from Imperial Valley into Guadalupe Lake at Betteravia. At first the animals multiplied, but with a succession of dry years the lake dried up. Some muskrats migrated to pools and swamps at the outlet of the lake and the Santa Maria River. Black Lakes, south of Oceano, San Luis Obispo County, also were planted with muskrats to reduce the growth of tules. The Santa Maria Valley is irrigated from wells, only excess water appearing in surface ditches, and the drainage basin is far removed from other streams. No damage to agriculture has resulted; a few hundred pelts were taken in 1936; predators are reported to capture migrating muskrats, and some were run over on highways by automobiles.

Little Lake, Inyo County.—William Bramlette imported individuals of the race *pallidus* (= *bernardi*) in 1928 to reduce cat-tails in the lake, which they have done; some have migrated along a connecting stream that sinks in the adjacent desert. No damage has occurred and the animals are far from other water or agricultural areas.

Lagoon near Sebastopol, Sonoma County.—Two animals were trapped in the winter of 1935–1936; no further information is available.

Taylorville, Plumas County.—W. H. Stanfords established a muskrat farm in Indian Valley in 1925, using native animals (subspecies *mergens*) from Honey Lake Valley, Lassen County. Some are known to have escaped into Indian Creek by 1929 (Dixon, 1929, p. 359).

Sierra Valley, Plumas and Sierra Counties.—Present at least since 1934 in the vicinity of Blairsden, Vinton, Loyalton; source unknown.

Contelenc, Butte County.—Ten pairs obtained from Colorado in 1929 were confined in a pen. Reported to have been taken by predators; none present in 1931 and no sign found on adjacent Little Butte Creek in January, 1936.

Oroville, Butte County.—Reported as present in one place on the Feather River in 1935; sign and animals seen in fair numbers during January, 1936; no evidence of muskrats found either above or below this locality.

Live Oak, Sutter County.—In January, 1938, a report was received of a muskrat having been shot near Live Oak, adjacent to the Feather River.

Princeton, Colusa County.—Four from McArthur were released here by H. G. Boyes about 1930 but “failed to make a start.”

McArthur, Fall River Valley, Shasta County.—A muskrat farm was established in 1930, four miles north of the town, on Mud Lake, by Mount Shasta Fur Farms. The valley contains a network of creeks and canals connected to the Fall and Pit rivers. Muskrat stock from Ohio, Colorado and North Dakota (according to employees of the farm) was first bred in pens. In 1931, 228 were released into a mesh-wire fenced enclosure and in 1932 others were added to a total of 599 (of these 374 were females). Muskrats were first reported outside the fence in 1933 but later inquiry brought reports of escapes in 1932 and possibly even in 1931. Five trappers employed by the California State

Department of Agriculture took 1818 muskrats in May and June, 1933, when funds for the work were exhausted; appeals for additional appropriations at a special session of the State Legislature were unavailing. Employees of Shasta County and a local power company took an additional 1148 rats that autumn, 496 of these within the fence. In the winter of 1933-1934, commercial fur trappers and a CWA project accounted for about 1800 more in the valley. Later trapping produced 4812 muskrats in 1934, and 3476 in 1935 that are of record. Muskrats, presumably from this source, are reported in Hat Creek, a southern tributary of Pit River, some miles to the west. Dams around springs and small levees about fields in the Fall River Valley were perforated by numerous muskrat burrows in 1933.

Redding, Shasta County.—Two animals were trapped adjacent to Sacramento River in 1935; subsequent search in 1936 of Pit River, which connects Fall River Valley with Sacramento River, failed to indicate muskrats in intervening territory.

Shasta Valley, Siskiyou County.—

About 1925 or 1926, muskrats were planted above Big Spring near Shasta River in the vicinity of Mayten. By 1931, muskrats had already spread down stream and were causing some damage to small dams on farms; one entered the intake of a water pump, which had to be overhauled in consequence! The Shasta River is tributary to the Klamath River.

Surprise Valley, Modoc County.—Two muskrat farms were established, one at Lake City (1926), another north of Fort Bidwell. By 1932 or earlier, muskrats had escaped to adjacent wet meadows and streams and caused minor difficulty by undermining temporary dams constructed to spread water on the sloping meadows. This area is separated by the Warner Mountains from the headwaters of Pit River.

Details given here, where not otherwise acknowledged, are from field observations by the author, supplemented by personal and written communications from federal, state and county agricultural officials concerned with rodent problems in California. Northern records for 1936 were secured by a trapper-observer employed by the State Department of Agriculture. W. C. Jacobsen, in charge of rodent control for the department, has aided greatly in the accumulation of records. To him and the other collaborators the author here expresses gratitude for the help rendered.



Fig. 62. Perforations due to muskrat burrows in dike about spring used for irrigation; Fall River Valley, Shasta County, California.

For many years the California quarantine law has contained a clause prohibiting entry of animals detrimental to horticultural or agricultural interests, and the game laws contain a provision that fur farmers should obtain annual licenses from the Division of Fish and Game; but these two laws were not rigidly enforced with respect to alien vertebrates. The muskrat situation in the Imperial Valley and reports of these animals in Kern County served to focus attention on the potentialities of the species. On May 15, 1929, notice was given by the Division of Fish and Game, at the suggestion of the State Department of Agriculture, that no permits would be granted for muskrat farming west of the Cascade-Sierra Nevada mountain system. Yet in February, 1930, a permit was granted for the Fall River Valley farm, on representation that adequate fencing would enclose the animals. Within two years (possibly less) muskrats were scattered over the valley.

In 1933, the State Legislature (Chap. 312) incorporated the regulation of 1929 in the California Fish and Game Code (Sec. 1323):

"It is unlawful to import or transport into, or possess any live muskrat (genus *Ondatra*) in the region west of the crest of the Cascade-Sierra Nevada mountain system, and west and south of the Tehachapi, Liebre, San Gabriel, San Bernardino, San Jacinto, Cuyamaca, and connected mountains south to the international boundary, or in any water shed tributary to or draining into the Pacific Ocean, except the drainage basin of the Klamath River. It is unlawful to import or transplant live muskrats into any part of California outside said region, except under permit issued by the [California Fish and Game] Commission. A county agricultural commissioner, fish and game deputy, or State plant quarantine officer may enter upon lands or waters where muskrats unlawfully exist, and remove or destroy muskrats thereon or therein."

The principal facts relating to introduction and spread of muskrats in California were brought to the attention of the general and agricultural public in meetings and through newspaper articles and radio broadcasts, without significant result.

In 1937, a bill (Senate 719) was introduced into the California Legislature proposing Fish and Game District 100 to comprise all inland lakes in Tehama County not having an outlet into any stream. Section 2 of this bill read, "Nothing in this code prohibits the raising of muskrats in the waters in district 100 * * *." The intent was to permit "farm" rearing of muskrats in this special district which is within the prohibited area of Sec. 1323 cited above. The bill failed to become a law.

Agricultural officials of the State and counties are aware of the problems arising from the presence of muskrats in irrigated regions, but, lacking public interest and financial support, no sustained attempt at eradication has been possible. Trappers and furriers consider the new supplies of muskrats advantageous.

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WEIGHT AND AGE DETERMINATION OF STRIPED BASS¹

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Many striped bass anglers are interested in knowing the age of the fish they catch, as evidenced by the numerous calls for the report by E. C. Scofield, "A Simple Method of Age Determination of Striped Bass."² This paper is now out of print so it was thought advisable to reconstruct the work, adding more material³ and changing the form of the chart somewhat. The bass angler can determine the approximate weight and age of his best fish by simply knowing the length of the striped bass from the snout to the fork of the tail, by using the accompanying chart, figure 63.

Usually you anglers carry a pocket rule so that you may measure your bass from the snout to the fork of the tail, to the nearest quarter-inch. Then take the chart, figure 63, find the inch scale on the left, corresponding to the measurement of the fish, and trace a course with your finger to the right on the same line until the curve is reached. There you will note between what ages the fish size falls. Then by following down to the pound scale, you can read the weight directly, so that you have obtained both age and weight in one simple operation. To illustrate, suppose your fish was 21 inches long. Then, by following out from left to right at the 21-inch mark, you hit the curve at a point just above the 5-year line; then tracing down to the pound line you find that the weight of the fish is about 4½ pounds. The chart works just as well in the other direction. If you know the weight—say 30 pounds—you find this number on the pound scale, follow it up to the curve where it strikes midway between 14 and 15 years old, then follow to the left and read the length at 42 inches.

Remember that this calculated curve and the age groups by sizes are averages and it may happen that your individual fish will be above or below average in age, weight or length, or perhaps it may be above average weight and below average length. These averages are based on large numbers so that they will give you approximate values for weight, length and age in the field where you have no scales available or no scientist to determine the exact age for your specific fish.

¹ Submitted for publication, December 29, 1937.

² California Fish and Game, vol. 18, no. 2, 1932.

³ We are indebted to the *Oakland Tribune* for the weight and length material which they furnished from the finals of their last two striped bass derbies in 1936 and 1937. All weights were used to the nearest quarter-pound, all lengths to the nearest half-inch measured over the body from snout to the fork of the tail. The weight-length curve was calculated from the formula $\log F + (\log L) x = \log W$, where F and x are constants determined from the data, L is the length and W is the weight. Little material was available beyond 25 pounds, but the calculated curve seems to fit what data we have. The age determinations are for average size of each year group from E. C. Scofield's work ("Striped Bass of California," Calif. Div. Fish and Game, Fish Bull. no. 29).

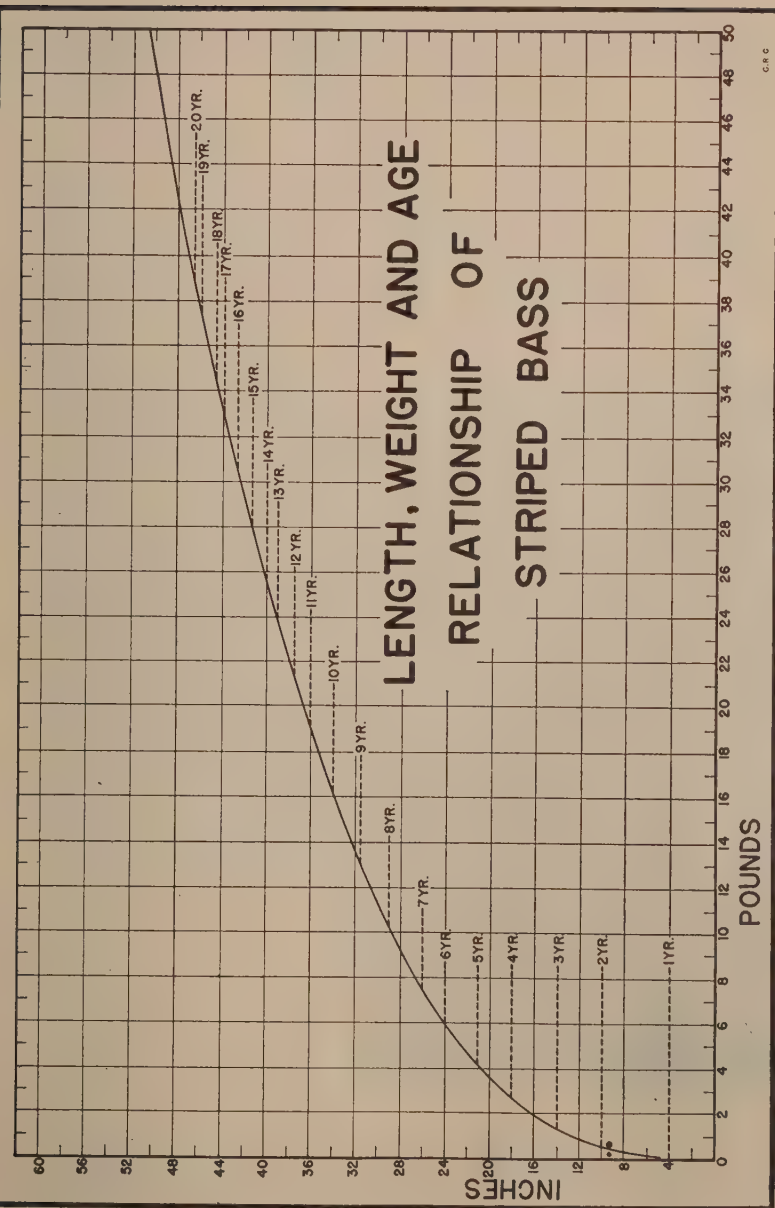


Fig. 63. The length, weight and age relationship of the striped bass of California. If you know either the length or weight of your fish, this chart will enable you to determine the other measure of size, as well as the approximate age.

"CHRISTMAS TREES" IN THE CALIFORNIA SARDINE FISHERY¹

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Since the opening of the present sardine season on August 1, 1937, there has been an apparent abundance of small sardines off central California. Young sardines are always present in these waters, but this year the fishermen have encountered greater numbers than usual.

These small fish gill in sardine purse seines and ring nets, occasionally to the extent that the webbing is almost obscured. When a purse seine is hoisted back aboard the boat on the boom, the suspended section assumes the general shape of a Christmas tree. Because the seething, silvery mass of struggling fish looks like ornaments sparkling under the bright flood lights, the fishermen coined the new expression, "Christmas tree," which has already become the standard term for a netful of gilled fish.

It is both a beautiful and a pitiful spectacle—pitiful when one considers that it takes hours of toil by the fishermen to "take down the ornaments," and that all the gilled fish are wasted. Canneries will not accept these fish because they are too small to can and their oil content is so low they can not be reduced profitably.

Sardines of similar sizes usually school together but in any school there may be a few individuals much larger or smaller than their

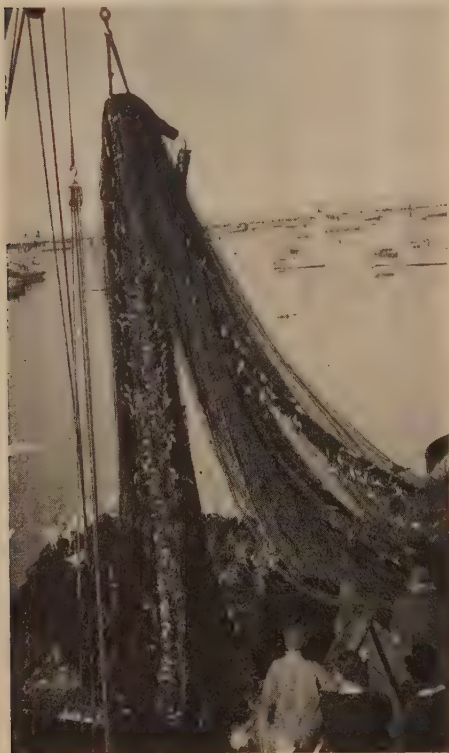


Fig. 64. Putting a sardine "Christmas tree" into a tanning vat at Monterey to boil out the gilled fish. A great many of the fish have already been removed by shaking the net. Photographed by J. B. Phillips, November 30, 1937.

¹ Submitted for publication, January, 1938.

companions. There are, therefore, all degrees of "ornamentation." When a net is set on average commercial sizes, there are usually a few small fish present which will gill. But the real "Christmas tree" occurs when a net is set around a school of predominantly small fish. It is difficult and frequently impossible for even the most experienced fishermen to determine whether the majority of the fish in a school are large or small before setting on them.

This situation has led to condemnation of fishermen as destroyers of our fish before they have grown to marketable sizes. In reality, the fisherman does not wish to set his net on small fish and avoids them whenever possible. As soon as the fishermen see that they have set on a school of small fish they let go of one end of the net so the fish which have not gilled can escape. The gilled fish increase the net's weight and drag to such an extent that it is extremely difficult to hoist it



Fig. 65. Gilled sardines in a purse seine at Monterey. The small fish on the deck are some that have been shaken from the net. Photograph by J. B. Phillips, November 30, 1937.

back aboard the boat. Occasionally a strong wind with resulting heavy seas increases the task to the extent that large pieces of netting have to be cut away in order that at least the lead and cork lines and part of the net can be saved. Nets have been torn to shreds by the weight of gilled sardines or anchovies. In at least one instance this season an entire net was lost off San Francisco. Removing fish from a badly gilled net is an enormous task, and if they are not removed within a few hours the net rots. When one considers that a modern sardine net costs from three to five thousand dollars, it is evident that fishermen think twice before "making a set."

Removing Gilled Fish from Nets

The usual method of "taking down the ornaments" is for several men standing abreast to shake short sections of the net violently. This may be done as the seine is slowly drawn in from the water over the turntable roller or after the entire net has been brought aboard. Shaking the webbing does not remove all the fish, however. The remaining fish are then either pulled out one at a time by hand, or the net is put into a tanning vat for eight to twelve hours. Tanning both preserves the net and cooks the gilled fish to a mush. Although tanning once or twice a month is good for a net, too much seems to have a harmful effect, so many fishermen prefer to pick all the fish out by hand. The final step is always to make a "blind haul" to wash out all slime and loose fish remains. Unfortunately, tanning a net costs money and fishermen may lose a night of fishing. Frequently, the vats are in such demand that one can not be obtained without waiting a day or two, so the fish must be pulled out by hand to prevent rotting of the net.

Preventative Measures

It has frequently been suggested that the mesh size of purse seines be increased in order that small fish can escape through the webbing. This seems impractical as larger fish would then become gilled with an increased danger of damaging the net. A number of fishermen have suggested a slight reduction in mesh size. Constructing the entire net of smaller mesh would not only increase its cost but would materially increase its drag through the water, making it extremely difficult to handle, especially in rough seas. Since most of the small fish gill in the upper forty to fifty feet of webbing, a practical solution may be to make only the top strip of webbing of smaller mesh. A strip of webbing is about 45 feet wide when hung. The mesh of most sardine nets varies from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches, stretched measure, when new. After tarring or tanning, the mesh shrinks to $1\frac{1}{4}$ to $1\frac{1}{2}$ inches. It is believed that if the mesh in the top strip of webbing were not over one inch after shrinkage the numbers of gilled fish would be few even if the net were set on a school of predominantly small fish. Of course, decreasing the mesh size would naturally result in gilling of smaller fish but the sizes which one-inch mesh will gill are apparently not very abundant in deep water where purse seines are operated. A further drastic reduction of the mesh size so that even very small fish can not gill would make a net the size of a modern purse seine impossible to handle due to its tremendous drag.

Occurrence

Although "Christmas trees" seem to be caught most often within two or three miles of the coast line, they have been observed over practically the entire area covered by the Monterey and San Francisco fleets, from Point Reyes southward, around the Farallon Islands, and on down the coast into Monterey Bay. Since the opening of the sardine season in southern California on November 1, 1937, some "Christmas trees" have been caught around the Channel Islands and along the mainland south of San Pedro. Their numbers are not, however, as alarming as in central California.

Explanations for Unusual Abundance of Small Sardines

The apparent abundance of small sardines off central California may be accounted for in several ways. Most explanations seem rather absurd at first thought, but all possibilities must be considered. Probably a combination of several factors rather than any one is responsible.

In the first place, large fish, in general, have been more difficult to find than usual off central California. Consequently, fishermen are liable to take a chance and set on fish whose sizes are doubtful rather than go days without wetting their nets. In any case, normal numbers of small fish with a scarcity of larger sizes would result in more schools of small fish being set on accidentally.

Furthermore, a rapidly growing fleet of purse seiners without a proportional increase in the number of schools leads to increased competition for fish, undoubtedly resulting in more sets being made on fish of questionable sizes.

Again, changes in fishing gear may have made the small fish more evident. Previous to the 1929-30 sardine season at Monterey, practically all the nets were lamparas,² which were made of smaller mesh than that used in present day purse seines and ring nets. Even if small fish had been abundant in the earlier days, sizes now gilling would not have gilled in the lamparas used at that time. The fact that fish are gilling now and causing fishermen no end of trouble may make their presence more apparent than in the past. However, this is the first season that small fish have been troublesome during the eight seasons that the gear consisted chiefly of ring nets and purse seines.

In addition, the sizes of gilled sardines indicate that most of them were hatched in the spring of 1936, at which time unusually warm water was present off Monterey. Warm water conditions to the north produce heavier northern spawning. Unfortunately, we do not know enough about the movements of young sardines to justify the assumption that these fish have remained for a year and a half near the locality where they hatched.



Fig. 66. Gilled sardines in a purse seine at San Francisco. Photograph by S. Ross Hatton, January 24, 1938.

² Phillips, J. B. Success of the purse seine boat in the sardine fishery at Monterey, California (1929-1930 fishing season). Calif. Div. Fish and Game, Fish Bull., no. 23, 28 pp., 1930.

On the other hand, favorable currents, temperature, or food conditions, during the summer and fall of 1937 may have resulted in an influx of small sardines from their more normal haunts, or if these fish usually pass through this area on their way to other regions, favorable conditions may have induced them to linger temporarily.

This may, then, be a localized condition not necessarily indicating a superabundance of small sardines considering the population as a whole. On the other hand, the fact remains that these fish may represent a superabundant year-class. But this is somewhat doubtful since these small sizes are apparently not outstandingly numerous in southern California waters this season. The history of the progress of this group through the fishery for the next few years may furnish the final answer.

The apparent exceptional abundance of small sardines off central California may, therefore, have been caused by any one, or a combination of factors: scarcity of large fish; a rapidly growing fishing fleet; changes in gear; or favorable oceanographic conditions which may have resulted in heavier local spawning or, at least temporarily, in an unusual concentration of these small sizes.

Sizes of Gilled Sardines³

It is impossible to obtain samples of sardines from any one source which will represent a true cross-section of the entire population. The nets used in the fishery are somewhat selective. Very small fish can escape through the meshes of purse seines and ring nets while slightly larger fish gill, leaving mainly adolescent and adult fish to get into the cannery catch. A few lampara nets are still being used at both Monterey and San Pedro to catch sardines and other species for the bait and fresh fish trade. These nets are usually set in fairly shallow water and catch mainly the smaller sardines. The fish school, at least to some extent, according to size. Schools of large fish may not habitually range in the same local areas as the smaller sizes so that lamparas fishing in shallow water may catch different portions of the population than larger nets set farther from shore.

In order to get a truer picture of the sardine population, samples have been measured from several sources and their size frequency distributions plotted for comparison in figure 67. The Monterey frequency polygons for samples taken at the fresh fish markets during the past fall and early winter have been combined in one curve. The San Pedro data have been treated in the same way. These market catches were made with lamparas. Measurements of gilled sardines have been made in the San Francisco, Monterey and San Pedro fisheries. Their frequencies are also shown. Two samples of sardines (not gilled) were measured at Monterey on November 2, 1937, from schools of predominantly small fish. These samples, taken with purse seines, were combined into one frequency.

Length frequency polygons of cannery sardines taken in the fall fishery at Monterey in past years⁴ reveal small fish during several

³At San Francisco, gilled sardines were measured by G. H. Clark and S. R. Hatton. The Monterey fish were measured by J. B. Phillips. F. N. Clark and J. A. Aplin measured the sardines in the San Pedro region. The author is indebted to these persons for their kind assistance in this work.

⁴Clark, F. N. Interseasonal and intraseasonal changes in size of the California sardine. Calif. Div. Fish and Game, Fish Bull., no. 47, 28 pp., 1936.

seasons. For small sizes less than 18 centimeters body length, the length frequency polygon for this season's fall fishery at Monterey is quite comparable to those of a few past seasons when the lampara net was the only gear used. The lampara may have occasionally fished in shallow water where these small sizes have usually been found, or the

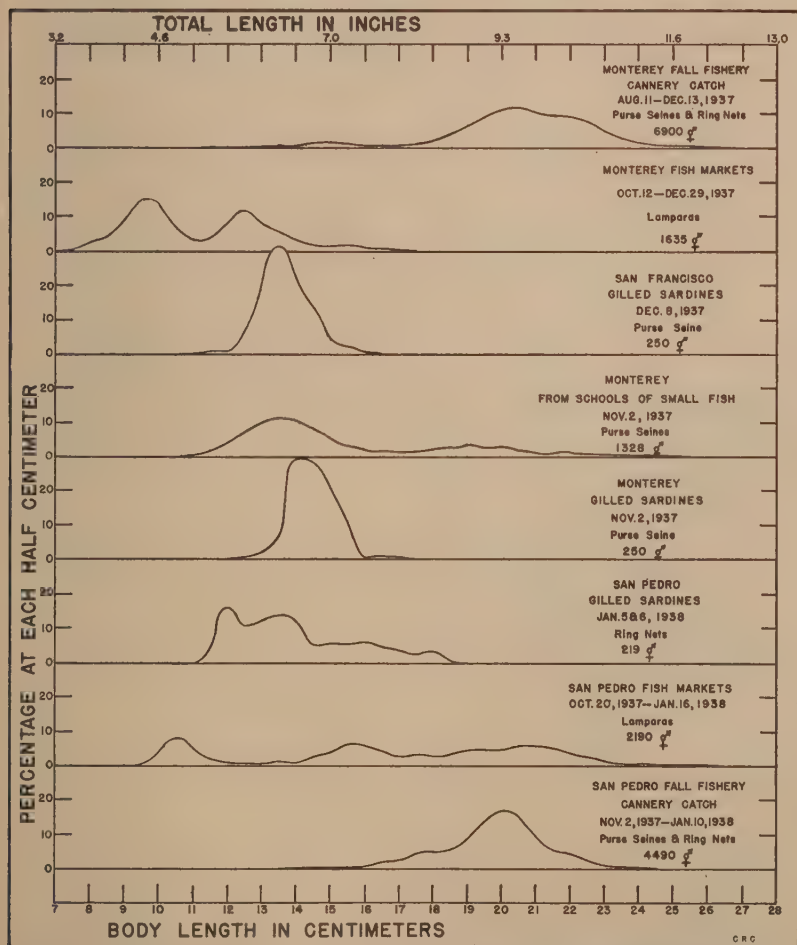


Fig. 67. Length frequency polygons showing sizes of gilled sardines compared with market and cannery catches. All measurements grouped to nearest half centimeter.

fish may also have been caught in the deeper water where the large present day seines are operated. If the latter is true, the present abundance can not be considered unusual.

The modes for the San Francisco and Monterey gilled sardines fall at points approximately midway between the upper of the two modes in the fish market frequency and the lowest mode of the can-

nery frequency. There may be several explanations. The most obvious ones are that possibly purse seines and ring nets gill only selected sizes of this particular group; or the smaller sizes of the group may school nearer to shore where the market boats fish, and bigger sizes farther at sea where the large nets are operated.

In contrast to Monterey, the frequency for San Pedro cannery sardines does not show a mode corresponding to sizes which gill in the nets. The frequency polygon for gilled sardines at San Pedro apparently includes fish from the two smaller size groups present in the San Pedro fish market frequency. As at Monterey, the gilled fish at San Pedro were taken from distinctly different fishing grounds than were the sardines delivered to the fish markets. This may possibly explain the difference in size distribution in the two frequencies. However, a more probable explanation is that the larger fish of the smallest group and the smaller fish of the next larger group are those which gilled in the ring nets from which the gilled samples were obtained.

On the basis of the frequencies for the sardines delivered to the fish markets at both Monterey and San Pedro, it seems evident that two distinct groups of young sardines are present in both localities. Only a small portion of the fish from the smaller groups gill in the meshes of ring nets and purse seines, the gilled fish coming chiefly from the larger of the two groups. The sizes of sardines which are gilling range from 11 to 17 centimeters, body length, or 5.1 to 7.9 inches, total length.

AN OUTLINE OF FISHING GEAR¹

By W. L. SCOFIELD

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A visitor new to California is often confused by the many kinds of gear used in ocean fishing along our coast. Not only is there variety in the fishing devices themselves but there is such diversity in names that the newcomer is led to believe there is more complexity than actually exists. Later on he learns that some of the English, Sicilian, Dalmatian and Portuguese names are merely duplications of terms applied to the same type of fishing gear. The confusion is still further reduced when he realizes that many of the devices are similar in the method by which they are operated and that two or more fishing appliances may differ only slightly in construction according to the manner in which they are to be used. The different devices for catching ocean fish may be grouped into related types according to use and it is the purpose here to present such an orderly arrangement in the hope that it will aid somewhat in reducing the misleading complications in kinds and names of gear. A description of the different devices will be left to a later publication in which we plan to give the characteristics of each kind of gear and to provide a glossary of terms used in connection with ocean fishing operations.

The outline here presented does not include a number of unusual kinds of gear used in foreign countries. For example, it makes no provision for the splash board used in connection with the Chinese trick of luring fish out of the water and into the fishing boat. It does, however, include a few illegal fishing devices occasionally attempted by an optimist before court fines dampened his enthusiasm.



Fig. 68. A trap for spiny lobsters, showing funnel entrance at the top of the trap. The man is holding a separate funnel from another trap. Photograph by G. R. Chute.

¹ Submitted for publication, January, 1938.

A few of the terms used in the outline need a little explanation because sea-going fishermen as well as fresh-water anglers are blessed with a picturesqueness of language of which exactness in meaning is not an outstanding characteristic. The term "fishing gear" obviously means all the apparatus and implements used in catching fish, except that as here used gear does not include the boat employed in the fishing operations. Incidentally fishing boats are commonly called by the name of the gear fished by them, as gill netter or purse seiner for example, and likewise the men of the boat are designated by the gear they operate so that fishermen may be otter trawlers, hand liners or trammel netters.

In fishing, the two words net and seine often may be used interchangeably. Our words net and knot are related and a net is a fabric

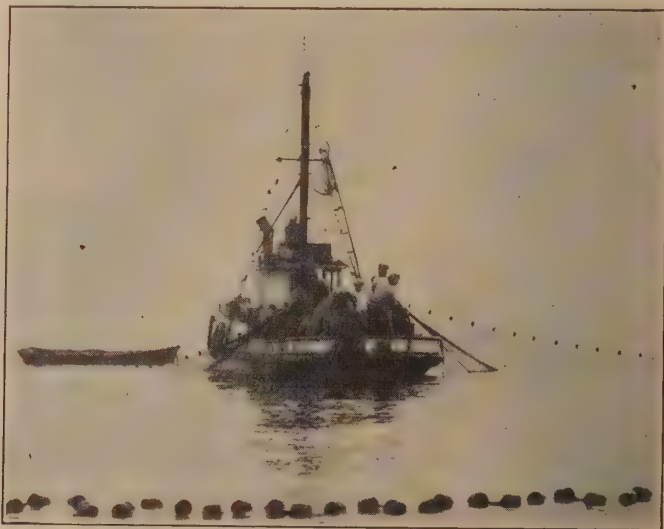


Fig. 69. Hauling a mackerel ring net. The bottom of the net has been pursed so the fish can not escape. The mesh does not show except where it is bunched. Photograph by D. H. Fry, Jr.

made by knotting cords leaving openings of uniform size. Such a fabric or net may therefore be used for confining fish, butterflies or straying locks of hair. In other words it is a very general term. A seine is a large net used to catch fish rather than butterflies, and it hangs vertically in the water with the upper edge buoyed by floats and the lower edge weighted. The word seine is therefore sufficiently general to warrant its application to many types of fishing nets.

A net when laid out, cast, circled or shot is said to be "set" or "in a set" and the captain or the boat itself is said "to set on" a school of fish, but this is not the use of the word "set" as applied in the classification of gear. A net or line is considered set when it is anchored or in some way attached to the bottom or shore so that it is not free to move with the water currents. By contrast a drift line or net has

no such fixed attachment to the bottom or shore and is therefore free to drift with any currents of the water.

Two simple words of similar sound but very different meaning are constantly confused—troll and trawl. Troll literally means wander or move about, but in fishing it is the moving through the water of a line with one or more hooks. Trolling is pulling a line with hooks through the water as from the stern of a boat while under way. A trawl is a bag net intended to be dragged along, usually on the bottom of the sea, so trawling is the dragging of such a net. Fortunately in this State we are spared the confusing application of the word trawl to a long stationary set line as is so frequent among fishermen in some of our eastern states.

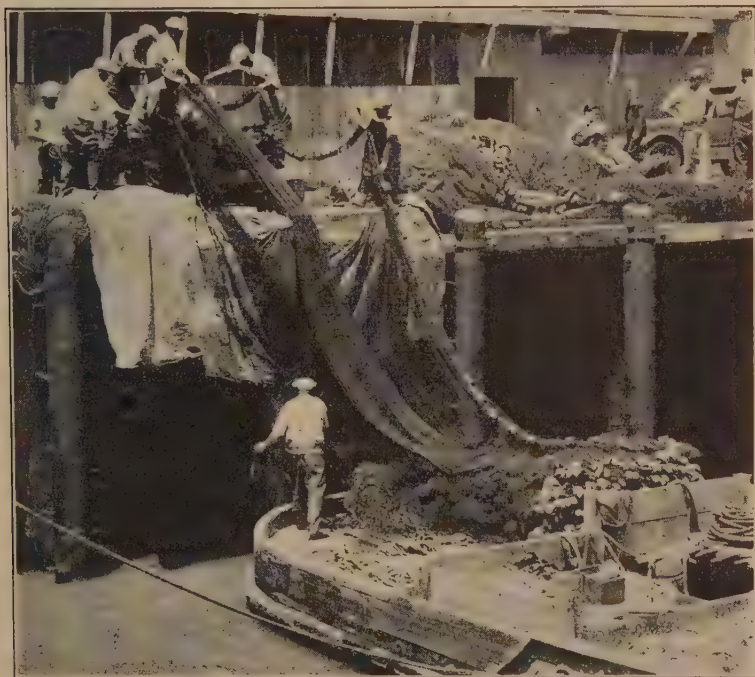


Fig. 70. Unloading a sardine ring net from a boat for tanning and mending. This net is over 1200 feet long. Photograph by D. H. Fry, Jr.

A fish trap is some sort of an impounding device, drifting or set, and the term may be applied to a great variety of such structures, most of which are not permitted under California law. Small traps for fish or lobsters may legally be used in parts of this State under certain circumstances, and such traps usually are built of wood slats or woven wire over a wood frame. A small trap constructed of cord webbing over hoops is anchored in streams but this, as well as the wicker trap fished by our Indians, is given the special name "fyke." Strictly speaking a fyke is a funnel-shaped entrance leading to a small opening difficult to find as an exit which is the principle used in a common form

of fly trap. The term fyke may be applied to any such funnel entrance in fishing gear and the anchored impounding traps used in some of our California streams are locally called fyke nets.

Entangling devices capture fish by two methods called gill and trammel. In a gill net the fish pokes his head into a small mesh of the net and when he attempts to back out finds that his extended gill covers are caught, thus the name gilling, but actually the fish is frequently found tightly wedged in the opening rather than caught by the gill cover. Trammel means to tie up or restrain in a confined space and a trammel net uses two or three walls of webbing, the inner curtain of small mesh hung slack with an outer wall of large mesh. The fish pokes the slack small mesh webbing through a large mesh of the outer wall and finds himself in a pouch or pocket of the net and so entangled that he can not execute a strategic retreat. An important difference between these two types of gear is that a gill net is obviously highly selective as to size of fish caught, whereas a trammel net entangles fish of a wide range of sizes.

In the outline the frequently used terms, circle net, round haul and haul seine, have been avoided because they are inclusive and do

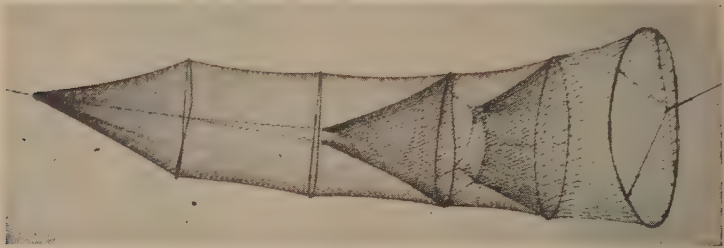


Fig. 71. A fyke net; open end at the right, bait at the left. This type of net is anchored in a stream. Once the fish have entered the net they find that the two funnels or fykes make escape difficult. Photograph by D. H. Fry, Jr.

not apply to any one kind of gear. The term circle net is occasionally useful in referring to the class of nets that are laid out in a circle until the two ends meet and are then pulled aboard a boat. Circle nets would then include the purse, lampara and ring nets but would exclude a gill net when fished in a circle, as it sometimes is. Round haul was originally applied in California to the lampara to distinguish it from the purse seine but now that the modified ring net has been evolved the term round haul has little meaning. Likewise the term haul seine is used too loosely and could apply as well to a beach seine as to any one of the three circle nets. The term half ring applied to a net is merely a survival from the time when lamparas had purse rings on one wing or half way around each wing. Since we no longer have nets ringed in this way, the term half ring should be dropped out of the picture following the gear to which the name once applied.

It should be pointed out that no arbitrary classification of gear can accurately cover each type of apparatus, because slight changes in construction or method of operating may convert one device into another or into a hybrid that in appearances resembles one parent but behaves

like the other. For example, a drift gill net in a stream is supposed to drift free with the current but an ingenious fisherman discovered that smooth rock weights attached by lines to the lead line of such a net would drag on the stream bed and retard the drift, yet these drags were not strictly anchors or fixed attachments to the bottom. In another sense the net resembled a vessel dragging her anchor. The courts ruled



Fig. 72. Mackerel fishing—the man in the foreground is using a pole line and hook, the other man is operating a dip net made of chicken wire. Photograph by Richard S. Croker, June, 1934.

that the rocks prevented the net from drifting free with the current and the gill net was thereby converted from a drift to a set net.

In spite of the variations in gear and the diversity in names the essential principles involved in capturing fish are simple. Man uses (1) a spear or related tool, (2) a hook, or (3) a net to confine in a small space or to entangle the victim.

OUTLINE OF FISHING GEAR

I. MISCELLANEOUS DEVICES

1. Spears—Gaff
2. Shooting—Dynamite
3. Poison
4. Snares
5. Diving
6. Rakes—Forks—Oyster dredges
7. Brush weirs
8. Traps

II. LINES

1. Pole (including kite line)
2. Hand (drop line)
3. Set (trot)
4. Drift
5. Troll (jig)

III. NETS

1. Impounding nets

a. Lifted

- (1) Dip nets
- (2) Hoop nets (including crab nets)
- (3) Blanket nets—Outriggers
- (4) Cast nets

b. Pulled

- (1) Beach seines (chinchola)
- (2) Purse seine
- (3) Lampara
- (4) Ring net
- (5) Trawl
 - (a) Beam
 - (b) Drag (paranzella)
 - (c) Otter

c. Set

- (1) Trap
- (2) Fyke
- (3) Chinese shrimp net

2. Entangling nets

a. Gill nets

- (1) Drift
- (2) Sunken—Submerged—"Diver"
- (3) Set—Anchored—Staked
- (4) Circled

b. Trammel nets

- (1) Drift
- (2) Set

REPORT ON THE CALIFORNIA OYSTER INDUSTRY FOR 1937¹

By PAUL BONNOT

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Humboldt Bay .

The 1937 season at Humboldt Bay (May to October) represents the third year in which a program of oyster research has been carried on with the local oyster, *Ostrea lurida*, and the biological material collected is the most complete so far obtained. Some pertinent facts are beginning to emerge from the study of the data of the last three years. As expected (Bonnot, 1937a) the 1937 set was comparatively light. No artificial collectors were used in the bay, but several carloads of dried Japanese oyster shell were laid out. A set was obtained in commercial quantity on this cultch; although nothing approaching the set of the 1936 season occurred.

The growing of native oysters in Humboldt Bay may be said to have passed the experimental stage, in so far as commercial production is concerned. The heavy set of 1936 is growing well with a small normal mortality. Considerable difficulty has been experienced in separating the young oysters caught on the new type of collector used (Bonnot, 1937b), and many of the spat have died from overcrowding. Experiments are now being conducted to obtain a formula for cement which will more readily separate from the wood after the setting is completed.

The collecting of data was carried on as in previous seasons, using the same stations as before. Samples of oysters were obtained once a week from the three stations to be tested for maturity, and the record of the spawning is complete for 1937. It was not possible to obtain a complete record of this phase of the work during the previous seasons, due sometimes to weather and sometimes to lack of equipment.

The 1938 season, from present indications, may show a much more prolific set than that of 1937, in which case several detailed experiments can be conducted which should add materially to our present knowledge.

The two active companies have imported eastern oyster seed during the last two seasons and some of the resulting oysters are now being marketed. Very few natives are as yet ready for market but it is expected that by the end of another season they will be available in some quantity. The eastern oysters did not "harden up" or become "fat" until early December and even then were not quite up to the usual standard. This condition, however, need not be considered as an indication that the easterns are not suited to the conditions in this bay. The fall of 1937 was unusually warm which would tend to delay "fattening." Also during some seasons many oysters do not become prime at all for reasons which are at present obscure. As the easterns

¹ Submitted for publication, January, 1938.

were all laid out on ground which was comparatively high, a bed in deeper water may react favorably for "fattening."

A third company, impressed with the possibilities of the bay, commenced operations in November and plans to have dikes and spat collecting equipment ready by the time the spawning starts in 1938.

The location of the three stations originally selected for collecting data and used continually for three seasons, was determined primarily by the proximity of natural oyster reefs. Although all three localities are subject to the general conditions prevailing in the bay, considerable differences appear when a comparison of the data is made. The only factor common to all three and different from the main bay is a slightly lower salinity due to incoming fresh water. The amount of this influx is different at each place, with a consequent difference in actual dilution.

Although all three localities are favorable to the growth of oysters, as demonstrated by the presence of natural reefs, the hydrographical conditions are sufficiently dissimilar to cause a difference in the rate of spawning and the time and intensity of setting. The salinity varies, of course, but the difference between the stations is very small. The temperatures probably do not vary to any extent, although this can not be definitely determined at present as only one recording thermometer is available.

A number of pertinent conclusions can be inferred or demonstrated from the present data. The oysters start spawning when the water temperatures reach a minimum of 13° C. This was also found to be true for the Puget Sound area. (Hopkins, 1937.) The spawning increases to a maximum in about two weeks' time and then slows up somewhat, although spawning oysters are present during the whole season. The swimming larvae start to set approximately thirty days after the spawning peak. The determining factor is apparently a series of neap tides followed by a series of spring tides. No correlation between the tide range and setting is evident. As spring tides consistently follow neap tides, a wave of setting which begins during a series of neap tides can be expected to reach a peak just previous to or during the following run of spring tides.

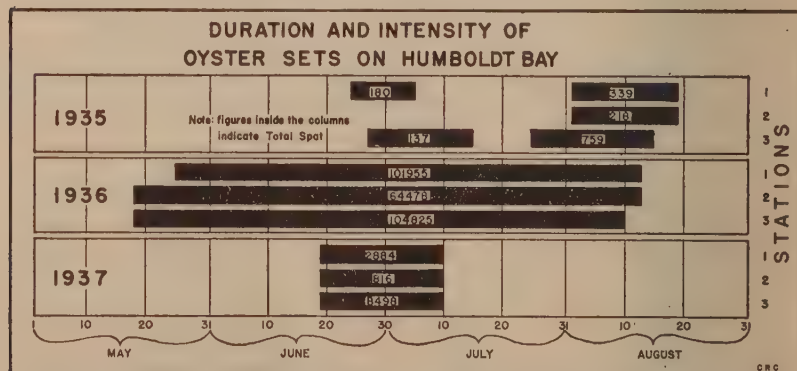


Fig. 73. The duration and intensity of the sets of native oysters, *Ostrea lurida*, at the three experimental stations maintained by the California Division of Fish and Game on Humboldt Bay, 1935, 1936 and 1937.

Data from other bays (Hopkins, 1937) demonstrate two waves of setting during a season. This has not occurred consistently at Humboldt Bay. Figure 73 illustrates the setting waves for all three stations during the three seasons. The horizontal bars indicate the approximate time extent of the setting waves and the figures give the total comparative size of set as shown by the shell bag counts. The year 1935 was at variance with the other seasons in time of set and was in accord with the data of other bays, showing two waves of set, the second greater than the first. There was considerable dissimilarity during all three seasons in the number of spat set at each station, as well as a great difference between seasons.

Station 3 (Eureka Slough) has a consistently higher spat fall than the other stations and this acts as a natural compensation to maintain the bed, as Eureka Slough with the largest influx of fresh water silts heavily during the winter with a consequent high mortality among the spat. It was estimated that during the winter of 1936, 75 per cent of the set of the previous season was killed by silting. An inspection of stations 2 and 3 during the summer of 1937 revealed little or no mortality at station 2 and a thriving cluster of young oysters on every pebble and shell fragment; whereas at station 3, clusters of old shell were covered with the dead valves of the previous season's set. The spring freshets seem to clear the silt away in Eureka Slough, leaving the bottom covered with comparatively clean shell ready for the next season's spat fall. Station 1 (Mad River Slough) falls between these extremes. The natural bed is a comparatively small local area surrounded by soft mud, but as the currents are strong the bed seems to maintain itself at a consistent numerical strength. Any silt carried over the bed is brought by the tidal currents, as the fresh water which is present in small amounts comes from seepage through several miles of swamp land, possibly from Mad River.

It was noted during the 1936 season (Bonnot, 1937a) that the swimming spat, once started on a setting cycle, do not set continually or uniformly, but attach themselves more plentifully at certain times than at others. That is, a bag of shell exposed for a period of a week will show one, two or three distinct age-classes. Some may have been attached for only a few hours while others may be four, five or six days old. There is seldom any gradation from one of these age-classes to the other. It can be concluded therefore that the larvae are attaching themselves to the cultch offered only during short periods, limited by a necessary combination of environmental factors. If it were possible to run a continuous hourly test during one of these spurts of setting much useful information might be gathered, and it was with this in mind that a test run was made at station 3 during July, 1937. As little is known concerning this phenomenon it would be a fortunate chance rather than deliberate calculation to hit one of these surges of setting. In the present instance the set had definitely stopped altogether and no second wave occurred. It is hoped that next season an opportunity may be presented to run several continuous hourly collections of data, if necessary through a period of 48 or 60 hours.

Bodega Lagoon

The growing of Japanese oysters, *Ostrea gigas*, during 1937 has progressed satisfactorily throughout the State. Plantings, totalling 3550 cases of seed, were made during the spring and everywhere the new seed is growing nicely.

In 1932 three small experimental plants of Japanese seed were made in Bodega Lagoon but the situations chosen were unfavorable and no returns were obtained. In 1936 a single test plant of 25 cases was laid out in what appeared to be a suitable location and, as the results were encouraging, a much larger planting was made in the spring of 1937. The oysters from the 1936 planting are now of marketable size and the 1937 seed is showing a very good growth. The principal need of the Bodega bed at present is a drastic culling as the oysters are still in the original clusters, resulting in crowding, which makes for many misshapen individuals and retarded growth. The seed on an individual shell of the original cultch is generally far too numerous to be allowed to grow *in situ*, as the oysters are all competing for food and space and the result is a number of long, narrow, thin-shelled oysters. If broken apart, not necessarily into singles, but into groups of four or less, the oysters have a chance to expand and grow, and a more uniform, round, deeply cupped shell is developed, with a correspondingly larger oyster.

From present indications, the Bodega bed seems to possess the necessary requirements for growing Japanese oysters successfully and in considerable quantity.

Tomales Bay

Tomales Bay has an old established oyster business based on eastern oysters, *Ostrea virginica*. Some effort was made, several years ago, to develop the indigenous natives, *O. lurida*, but the activities of the introduced eastern oyster drill, *Urosalpinx cinerea*, made the attempt abortive. Plantings of Japanese seed were started in 1933 by the company handling the easterns. Their Japanese beds are now of some extent and they have been marketing the oysters for several years. Several other plants of Japanese seed have been made by other individuals in other parts of the bay with satisfactory results. The available area in Tomales Bay suitable for growing oysters is limited, due to topographical features and although the bay is not at present producing to capacity the most favorable locations are already under cultivation.

Drakes Estero

In 1932 and 1933 several test plants of Japanese seed were made in Drakes Estero. These were so successful that a corporation was formed and larger plantings have been made during the last several years. In common with most attempts to adapt exotic species to a strange environment, mistakes were made at first in the selection of suitable areas, but after several years of trial and error the merits and demerits of various parts of the bay have been determined. At present the beds are in a flourishing condition. Oysters have been marketed in increasing numbers from these beds for several years.

The available growing area of the bay is extensive and there is still ample space for expansion.

San Francisco Bay

Only one company cultivates oyster beds in San Francisco Bay at present. They have handled eastern oysters for many years. They started with Japanese seed in 1933, and have made several large plants. The Japanese oysters grow more slowly in San Francisco Bay than in some of the other localities and acquire a greenish tinge, due perhaps to copper salts. This coloring does not affect their edibility in any way. Eastern oysters held in the bay for any length of time also become tinged with green. The native oyster, although plentiful, does not grow to a sufficient size to be marketable. As the bay is heavily infested with the eastern oyster drill, brought in with the first introductions of eastern oysters, any attempt to cultivate the natives would start under a disadvantage and the cost of production would be considerably higher in consequence.

Morro Bay

Test plants of Japanese seed were first made in Morro Bay in 1932. Despite the absence of any systematic attention these oysters grew very well until picked up and sold by poachers. In the spring of 1937 a test plant of 50 cases was made and these have been carefully tended. They have done very well, and as there is considerable available area the bay may become an important oyster growing location.

Newport Bay

In the spring of 1937 a test plant of 50 cases of Japanese seed was laid out in Newport Bay. The oysters have shown a larger growth than those in more northern bays, due perhaps to the prevailing higher water temperatures. Because of the higher water temperatures, however, they have not hardened up so well. It may be that the marketing season for these oysters will be confined to the colder months of winter, as the approach of cold weather seems to cause oysters to harden or fatten.

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NOTES

VOLUME 24

APRIL, 1938

Number 2

THE 1937 PISMO CLAM CENSUS

The annual census of Pismo clams, *Tivela stultorum*, at Pismo Beach was taken by the staff of the California State Fisheries Laboratory on November 17-19, 1937. Age determinations were made at the Laboratory, and, following the custom of the past two years, clams aged without injury were replanted on a southern California beach. Included were 1080 individuals, of which 731 were clams of the year. This is the largest of the three plants.

The total number of clams taken was the greatest in many years. A very strong incoming year class following so shortly after the large set of 1935 is responsible for this. In all, 1179 clams were counted. Of these, 63.4 per cent were clams of the year, 8.7 per cent one-year, 21.0 per cent two-year, 0.6 per cent three-year, 1.6 per cent four-year, 0.6 per cent five-year, 2.7 per cent six-year, and 1.4 per cent seven years or older. As is usual, the bulk of the year's set was found on the portion of the beach that is open to digging. There it represented 105 per cent of the 1935 set. In the area closed to digging it was but 86 per cent of 1935, the set for the entire beach equalling 97.0 per cent of that year's set. The individuals of the incoming class were noticeably smaller than is usual, the average size falling at 14.9 mm. and the range extending from 8 to 26 mm. A size more in accordance with expectancy was shown by the incoming group taken at the same time of year in 1936, the mean of that group falling at 21.6 mm., while the range was 13 to 37 mm. Whether a late set, unfavorable water conditions, lack of food or other factors are responsible for the small size noted this year is a matter of conjecture.

The large 1935 class shows a better survival rate in the open area than did the strong 1929, 1930 and 1931 classes at the same age: 33 per cent compared with 18 per cent. However, in the closed area the opposite holds true for but 29 per cent of the 1935 class survived as against 35 per cent of the 1929, 1930 and 1931 classes at the age of two years. The number of spawning clams (clams four years and older) present in the closed area is but half of what it was in 1936 and 80 per cent of 1935. Clams of legal size formed 17 per cent of the total compared with 22 per cent in 1936. In the open area, no clams of legal size were found, and those four years and older were but 37 per cent of 1935. A further decrease in the number of spawning clams in the open area may be expected in 1938, as nearly all of the survivors of the large sets of 1929, 1930 and 1931 will have entered the legal catch by that time, the 1933 class will be reaching legal size, and will be removed

immediately and the incoming spawning group (1934 class) is negligible.

The most encouraging feature of this year's census was the discovery of the good set for 1937. There have been but two really poor sets since 1929—those of 1932 and 1934—whereas those of 1931 and 1935 as well as 1937 have been exceptional. On the other hand, the drop in number of spawning and legal-sized clams in the closed area is disappointing. From 1929, when the area was closed, to 1933 clams of legal size were very scarce, forming not over 2 per cent of the population. A steady increase followed, and in 1936, 22 per cent were of legal size. Although the drop noted this year is not great, it does dampen hopes that the area might be repopulated to something of its former status. With the succession of large sets of the past few years the potential future of the population is very good. However, a continued decrease may be expected in years to come if public opinion in the Pismo area continues indifferent, for more adequate protection against the poaching which is known to be taking place can be given only with the cooperation of the local residents. In their hands lies the ultimate fate of the beach.—*P. M. Roedel, California State Fisheries Laboratory, January, 1938.*

PINK SALMON IN CALIFORNIA

Pink or humpback salmon, *Oncorhynchus gorbuscha*, are only rarely found in California, being abundant only from Washington north to Alaska. Hence, it is felt that reports of considerable numbers running in northern California streams in 1937 should be made a matter of record. The last previous California specimen was reported in 1933 from the egg-taking station of the U. S. Bureau of Fisheries on Mill Creek, a tributary of the Sacramento River.

On October 8, 1937, Captain J. D. Dondero of the California Division of Fish and Game, Eureka, sent a small salmon to the San Francisco office for identification. The fish proved to be a mature female pink salmon, eighteen inches long. It had been taken on a spinner in tidewater of the Mad River, Humboldt County.

Following the receipt of the above fish some additional reports of humpback salmon were sent in by two Division of Fish and Game wardens in the North Coast area.

Warden Ovid Holmes of Fort Bragg reported as follows:

"The humpbacks were first noticed this year (1937) in the Ten Mile and Garcia rivers about October 1. In the Ten Mile River they were seen spawning about five miles upstream from the mouth. I might say also that there was quite a run of them, ranging in size from three to six pounds. Many people were interested in knowing what kind of fish they were, and whether they all took my explanation as to the species, I could not say. I might also say that seven years ago I caught a male of the same species in the Ten Mile River on November 7, and one the following year on February 6. I have not seen or heard of them since those two years in the streams along the Mendocino Coast until this fall. Also there seems to be a much larger run of them this year than in the previous years mentioned. Whether this is true or not I can not say for sure, as in the previous years the water was roily

as we had had several freshets and the fish could not be seen. However, this year the water was clear and many quite large schools of them were seen, causing quite a lot of talk around here. There is no doubt the fish hit this section every so often and spawn here. Further than that I can not tell you any more about them."

Warden Leo Mitchell of Point Arena also sent in a report. He states, "On September 26, I was told of a large run of unknown fish in the Garcia River. I went to investigate on the 27th and found them spawning all over from the Red Bridge to the western boundary of the Indian Reservation, a distance of about two miles. The water was rather low and beds quite mossy. I found females without and males with a hump working hard on the beds. The run seemed large. I would say that on September 27 and October 1 and 2, when I was patrolling the river quite closely for trout fishermen, I saw several hundreds. Finally I found a dead male but it was too far gone to send in. It was 23 inches long, 8 inches wide at hump, gray in color and with teeth in upper and lower jaws. I could not count the scales, pyloric caeca, or soft rays in the anal fin. A particular fact is that black spots covered all fins and the tail.

"On the third of October I tried to make a count of the number of fish but it was very difficult. During one hour near Windy Hollow Ford I counted 116. I became immensely interested and inquired about other coastal streams. Warden Holmes told me of their presence in the Ten Mile River and Warden Von Arx said they were in the Russian River. I saw them myself in this river, milling around on the riffle at Lone Tree west of Monte Rio on October 6, and then just under the bridge at Monte Rio on October 22. They had disappeared from the Garcia around the fifteenth of October. As far as I can tell, six were caught by sportsmen before I came back and were found to be good eating but poor fighters. I saw two brought to the Point Arena Inn."

The foregoing descriptions of the fish are not sufficiently detailed to make certain the identification as to species. However, both Wardens Mitchell and Holmes have had long experience and are thoroughly familiar with the fish normally present in the streams. The information is therefore thought worthy of record.—A. C. Taft, *California Division of Fish and Game, December 11, 1937.*

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1937, to December 31, 1937, of the Eighty-ninth Fiscal Year

Revenue for Fish and Game Preservation Fund:

Current Year:

Licenses:	Detail	Total
Angling licenses, 1938	\$141 00	
Angling licenses, 1937	285,340 55	
Commercial hunting club licenses, 1937-1938	900 00	
Commercial hunting club operators' licenses, 1937-1938	280 00	
Deer tag licenses, 1937	86,808 00	
Fish breeders' licenses, 1937	40 00	
Fish importers' licenses, 1937	20 00	
Fishing party boat permits, 1937-1938	186 00	
Fish packers' and wholesale fish dealers' licenses, 1937-1938	1,010 00	
Game breeders' licenses, 1938	2 50	
Game breeders' licenses, 1937	117 50	
Hunting licenses, 1937-1938	228,139 75	
Hunting licenses, 1936-1937	19,982 50	
Kelp licenses, 1937	20 00	
Market fishermen licenses, 1937-1938	40,790 00	
Trapping licenses, 1937-1938	1,919 00	
Total licenses		\$665,696 80
Other revenue:		
Court fines	\$27,284 94	
Fish packers' tax	103,559 92	
Fish tags, 1937	1,767 24	
Game tag sales	161 34	
Interest on bank balances	712 73	
Kelp tax	145 25	
Lease of kelp beds	384 66	
Miscellaneous sales	2,756 87	
Publication sales	15 01	
Salmon tax	20,880 49	
Total other income		\$157,668 45
Grand total current year revenue		\$823,365 25

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to December 31, 1937, of the Eighty-ninth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Operating Expenditures—89th Fiscal Year:					
Administration:					
Accident and death claims.....			\$485 01		\$485 01
Cashier.....	\$300 00				300 00
Executive.....	2,499 96	\$57 91	1,370 67		3,928 54
Exhibits.....			1,200 00		1,200 00
General office.....	3,681 33	2,463 38	9,605 23	\$66 44	15,816 38
Legal.....			2,394 17		2,394 17
Library.....	900 00	1 71	60 74	250 79	1,231 24
Property inspection.....		2 00	86 70		88 70
Prorata department accounting.....	5,000 00		6,000 00		11,000 00
Prorata General Fund expense.....			2,752 46		2,752 46
Publicity.....			2,001 82		2,001 82
Total Administration.....	\$12,381 29	\$2,525 00	\$25,965 80	\$326 23	\$41,198 32
Patrol and Law Enforcement:					
Cannery inspection.....	\$10,266 86	\$379 04	\$1,692 74		\$12,338 64
Executive.....	7,110 00	372 66	1,385 84	\$65 28	8,933 78
General office.....	2,805 48	240 93	1,689 93	134 91	4,871 25
Junior patrol.....	1,423 12	152 19	352 73		1,928 04
Land patrol.....	92,540 04	16,654 20	31,929 31	13,331 76	154,455 31
Marine patrol.....	23,400 82	9,877 74	14,304 98	2,074 07	49,657 61
Pollution patrol.....	3,104 19	858 43	2,040 44	124 99	6,128 05
Total Patrol and Law Enforcement.....	\$140,650 51	\$28,535 19	\$53,395 97	\$15,731 01	\$238,312 68
Marine Fisheries:					
Executive.....	\$3,660 00	\$107 82	\$230 35		\$3,998 17
Field supervision.....	1,640 00	157 14	1,458 87		3,256 01
Fish cannery auditing.....			660 95		660 95
General office.....	4,008 01	92 04	495 44		4,595 49
Research and statistics.....	18,602 10	1,883 62	5,098 99	\$1,311 67	26,896 38
Total Marine Fisheries.....	\$27,910 11	\$2,240 62	\$7,944 60	\$1,311 67	\$39,407 00
Fish Conservation:					
Cooperative Research-Stanford University.....	\$979 67	\$175 12	\$333 88	\$44 05	\$1,533 62
Executive.....	3,180 00	121 42	309 58	915 90	4,526 90
Field supervision.....	5,055 06	465 06	2,162 66	605 27	8,288 05
Fish planting.....	2,601 22	1,046 25	1,630 31	4,334 24	9,612 02
Fish rescue.....	3,367 85	418 74	1,142 12	208 33	5,137 04
General office.....	2,397 41	24 75	36 27	173 67	2,632 10
Pollution inspection.....	1,560 00	179 03	443 02		2,182 05
Research.....	1,282 42	81 39	489 21	87 22	1,940 24
Statistical.....	1,140 00		477 50		1,617 50
Alpine Hatchery.....	897 23	636 09	159 47	550 65	2,243 44
Basin Creek.....	2,202 61	1,123 88	285 05	541 78	4,154 22
Beaver Creek Egg Collecting Station.....	250 00				250 00
Beaver Creek.....	148 55	46 90	8 58		204 03
Big Creek.....	1,561 67	922 18	167 25	543 45	3,194 55
Blackwood.....	272 81	218 39	1 00		492 20
Blue Lakes Egg Collecting Station.....	400 00		16 00		416 00
Bogus Creek Egg Collecting Station.....		14 00			14 00
Brookdale.....	1,320 32	1,109 03	201 07		2,630 42
Burney Creek Hatchery.....	2,613 27	882 61	311 48	552 66	4,360 02
Carmen Lake Egg Collecting Station.....	312 00	2 24	10 43		324 67
Central Valleys.....	1,513 31	1,119 85	992 23	527 39	4,152 78
Cold Creek.....	2,468 27	1,695 42	466 08	579 48	5,209 25
Cottonwood Lakes Egg Collecting Station.....	83 87	11 10	75 23		170 20
Fall Creek Egg Collecting Station.....		19 61	85 00		97 61
Fall Creek.....	2,041 13	1,638 82	181 44	6 06	4,767 45
Feather River.....	2,089 55	791 50	264 35	164 35	3,309 75
Tahoe.....	2,980 35	1,245 13	369 82	43 23	4,638 53
Fern Creek.....	912 71	347 00	56 27		1,315 98
Fishing Creek Experimental Station.....	358 06	22 25	5 31		385 62
Forest Home.....	5,597 51	6,593 25	997 08	34 47	13,522 31
Fort Seward.....	1,968 71	697 40	98 05	673 95	3,438 11
Hornbrook Egg Collecting Station.....		41 03			41 03
Hot Creek.....	1,440 81	954 46	127 36		2,522 63
Huntington Lake.....	246 00	253 15	156 40		655 55
Kaweah.....	2,375 32	563 81	736 59	52 06	3,727 78
Kings River.....	2,725 98	1,057 32	775 01	35 12	4,593 43
Klamathon Egg Collecting Station.....	1,412 91	121 48	324 58	12 21	1,871 18
Kosk Creek Egg Collecting Station.....		8 44			8 44

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to December 31, 1937, of the Eighty-ninth Fiscal Year -Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Lake Almanor	\$3,046 17	\$1,200 60	\$251 21	\$133 58	\$4,631 56
Lake Eleanor Egg Collecting Station		18 94			18 94
Little Walker Lake Egg Collecting Station	259 03				259 03
Madera	439 84	432 55	243 83		1,116 22
Marlette Lake Egg Collecting Station	713 17	4 79	26 35		744 31
Mount Shasta Exp. Hat	361 29	426 21	25 09		812 59
Mount Shasta	14,369 73	9,310 24	1,963 84	115 00	25,758 81
Mount Tallac	692 32	715 81	30 60		1,438 73
Mount Whitney	5,248 64	3,247 83	1,822 93	730 49	11,049 89
Mud Creek Egg Collecting Station	9 21				9 21
Prairie Creek	2,475 13	754 80	386 55	587 05	4,203 53
Rush Creek Egg Collecting Station	369 33	49 81			419 14
Scott Creek Egg Collecting Station	750 00	77 04	87 03		914 07
Shackleford Creek Egg Collecting Station		31 25	50 00		81 25
Shasta River Egg Collecting Station	293 54	41 13	95 20	6 64	436 51
Shasta River Experimental Station	152 00	53 17	49 23		254 40
Snow Mountain Egg Collecting Station		31 50	1 00		32 50
Waddell Creek Station	231 94	12 36	27 09		271 39
Warner Creek Station	9 21				9 21
Yosemite	1,889 55	707 81	152 25	9 84	2,750 45
Yuba River	1,651 80	610 99	200 18	3 12	2,466 09
Total Fish Conservation	\$93,618 48	\$42,667 93	\$19,308 96	\$12,272 16	\$167,867 53
Hydraulics:					
Engineering	\$2,250 00	\$262 51	\$1,080 72	\$1,502 27	\$5,095 50
Executive	2,010 00	150 98	449 20		2,610 18
Fish screens		144 55		1 64	146 19
General office	960 00	45 88	38 21	147 31	1,191 40
Total Hydraulics	\$5,220 00	\$603 92	\$1,568 13	\$1,651 22	\$9,043 27
Game Conservation:					
Elk refuge	\$1,188 32	\$119 07	\$299 79	\$131 81	\$1,738 99
Executive	5,627 48	373 21	1,062 15	27 77	7,090 61
Field				17 06	17 06
Game bird distribution	800 00		207 04		1,007 04
General office	2,412 44	115 54	10 57	103 06	2,641 61
Grey Lodge refuge	1,920 00	343 80	119 33		2,383 13
Imperial refuge	720 00	80 95	45 54		846 49
Los Banos refuge	1,497 16	326 59	365 22	47 22	2,236 19
Los Serranos game farm	6,449 90	3,449 85	1,680 25	767 88	12,347 88
Predatory animal control	15,331 19	2,102 42	5,729 79	32 52	23,195 92
Research	272 74	39 45	553 36		865 55
Suisun refuge	940 00	353 87	259 80	114 82	1,668 49
Winter feeding and salting of game		190 30			190 30
Yountville game farm	7,564 31	6,517 23	2,139 18	210 98	16,431 70
Total Game Conservation	\$44,723 54	\$14,012 28	\$12,472 02	\$1,453 12	\$72,660 96
Licenses:					
Executive	\$1,650 00		\$23 14		\$1,673 14
General office	733 67	\$79 99	1,724 60	\$2,093 90	4,632 16
License distribution	5,391 02	13,139 50	32,367 78	91 67	50,989 97
Total Licenses	\$7,774 69	\$13,219 49	\$34,115 52	\$2,185 57	\$57,295 27
Special Item—Construction of research boat					\$3,000 00
Total 89th Fiscal Year Expenses paid from Support Appropriations					\$628,765 03
Expenditures for Additions and Betterments:					
Permanent Improvements:					
Purchase of game refuges and public shooting grounds and C.I.E. Chap. 157-37	\$470 00	\$714 58	\$1,462 31	\$24 68	\$2,671 57
Contributions to Employees' Retirement System					9,203 26
Total Current Biennium					\$640,659 86

STATEMENT OF EXPENDITURES

For the Period July 1, 1937, to December 31, 1937, of the Eighty-ninth Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Prior biennium appropriations:					
89th Fiscal Year:					
Special Item—Expenses of California Code Commission, Chap. 645-33					\$0 37
88th Fiscal Year:					
Special Item—Construction of Russian River Jetties, Chap. 989-33					365 84
Support:					
88th Fiscal Year				\$56,166 16	
87th Fiscal Year				16 62	
Total Support					\$56,182 78
Special Item—Predatory Animal Control, 88th Fiscal Year					3,426 15
Expenditures for additions and betterments, permanent improvements, purchase of game refuges and public shooting grounds and C. I. E., 88th Fiscal Year					18,141 67
Total Prior Biennium Appropriations					\$78,116 81
Grand total					\$718,776 67

SEIZURES OF FISH AND GAME

October, November, December, 1937

FISH:		GAME:	
Abalone	238	Antelope head	1
Bass, black	103	Bear skin	1
Bass, striped	159	Curlew	5
Bass, striped, pounds	130	Deer	41½
Catfish, pounds	6	Deer head	1
Clams	919	Deer meat, pounds	1,064
Cockles	220	Doves	136
Crabs	22	Ducks	72
Flounders	2	Elk	1
Halibut, pounds	106	Geese	2*
Lobsters	819½	Godwit	1
Lobsters, pounds	2,233	Grebe	2
Lobster pots	71	Grouse	1
Lobster receivers	16	Meadowlark	4
Lobster traps	94	Mink hides	3
Salmon	61	Mudhens	29
Sheepshead, pounds	220	Muskrat pelts	19
Sunfish	16	Pheasant	38
Trout	177	Quail	257
Trout, pounds	14	Rabbit	34
Tuna, yellowfin, pounds	6,705	Robins	2
		Sandpipers	12
		Sparrow	14
		Swan	3
		Towhee	1
		Willetts	2
		Yellowhammer	1

GAME CASES

October, November, December, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Antelope; possession	1		
Bear; closed season	2	\$50 00	
Deer; evidence of sex removed; failure to fill out tag; failure to retain hide and horns; dogs killing deer in refuge; closed season; mutilating tags; offering hides for sale; transporting illegally; no tags; tags not countersigned; killing, possession doe, fawn, forked horn in Dist. 1 $\frac{3}{4}$, spike buck	140	5,736 00	281 $\frac{1}{4}$
Doves; closed season; overlimit	10	347 50	
Ducks; closed season; operating commercial club without license; overlimit	25	650 00	
Firearms in refuge	53	1,046 00	2
Geese; closed season	2	10 00	
Grouse; possession	1	50 00	
Hunting; closed season; night hunting; in refuge; making false statement to procure license; no license; transferring license; failure to show license on demand; using another's license	127	1,666 50	89 $\frac{1}{2}$
Illegal shooting	34	535 00	30
Mink; closed season	2	10 00	5
Mudhens; closed season	5	55 00	
Muskrat pelts; illegal possession	2		
Nongame birds; closed season; killing, possession	14	335 00	
Pheasants; closed season; overlimit; selling	36	1,275 00	40
Pigeons; closed season	1	100 00	
Protected birds; possession	31	660 00	25
Quail; closed season; overlimit; selling	33	1,290 00	50
Rabbits; closed season	7	132 50	
Spotlight hunting	5	325 00	90
Trapping birds	2	25 00	
Trapping; no license	3		
Trespassing	9	200 00	
Using cane gun	1	25 00	
Totals	546	\$14,523 50	612 $\frac{3}{4}$

FISH CASES

October, November, December, 1937

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalone; closed area; out of shell; overlimit; undersize	37	\$490 00	32
Bass, black; overlimit; undersize	8	120 00	
Bass, striped; overlimit; undersize	38	770 00	
Catfish; selling undersize	1		
Clams; out of shells; overlimit; undersize	39	1,223 50	397
Cockles; overlimit	1	25 00	
Commercial fishing; no license	73	880 00	60
Crabs; closed season; undersize	8	120 00	
Fishing; disturbing nets; failure to record fish purchases; closed area; closed season; from dam; too near dam, ladder; no license; night fishing; using another's license; using fresh trout roe; using prohibited gear	149	2,963 50	166 $\frac{1}{2}$
Frogs; undersize	1	25 00	
Halibut; undersize	1	10 00	
Lobsters; closed season; oversize; undersize	33	765 00	625
Pollution	15	1,125 00	
Salmon; closed season; overlimit; selling; shooting; spearing; taking on spawning area	32	775 00	285
Trout; overlimit	6	120 00	
Totals	442	\$9,412 00	1,565 $\frac{3}{4}$

**FRESH FISH IMPORTATIONS* FROM FOREIGN COUNTRIES
FOR OCTOBER, NOVEMBER AND DECEMBER, 1937**

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Landed in Region 70, Los Angeles	Landed in Region 80, San Diego	Total pounds
Barracuda.....	328,034	222,858	550,892
Cabrilla.....	15,113	1,874	16,987
Corbina, Mexican.....	738		738
Grouper.....	3,678	306	3,984
Halibut, California.....	3,566	42,399	45,965
Mackerel, Pacific.....		1,239	1,239
Mackerel, Spanish.....	14,875	4,177	19,052
Perch.....		215	215
Rock Bass.....	9,780	7,400	17,180
Rockfish.....		14,108	14,108
Sardine.....		90	90
Sea-bass, Black.....	99,714	44,812	144,526
Sea-bass, Totuava.....	588,454		588,454
Sea-bass, White.....	10,481	133,341	143,822
Shark.....	1,189	995	2,184
Sheepshead.....	207	3,911	4,118
Smelt.....		1,319	1,319
Swordfish, Broadbill.....		4,645	4,645
Tuna, Albacore.....	234,731		234,731
Tuna, Bluefin.....	670	2,840	3,510
Tuna, Bonito.....	190,381	641,835	832,216
Tuna, Oriental.....	104,162		104,162
Tuna, Skipjack.....	1,738,759	9,790,088	11,528,847
Tuna, Yellowfin.....	3,421,675	13,649,638	17,071,313
Whitefish.....	711	15,796	16,507
Yellowtail.....	91,378	887,267	978,645
Miscellaneous fish.....	707		707
Crustacean:			
Lobster, Spiny.....		305,657	305,657
Shrimp.....	2,090		2,090
Total pounds.....	6,861,093	25,776,810	32,637,903

* These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

FRESH FISH IMPORTATIONS BY POINT OF ORIGIN* FOR OCTOBER, NOVEMBER AND DECEMBER, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Gulf of California	West coast Lower California	International waters south U. S. boundary (definite origin unknown)	Mexican mainland, Central and South America	Japan	Total pounds
Barracuda		222,858	328,034			550,892
Cabrilla	3,545	1,874	11,568			16,987
Corbina, Mexican	738					738
Grouper		306	3,678			3,984
Halibut, California		42,399	3,566			45,965
Mackerel, Pacific		1,239				1,239
Mackerel, Spanish		4,177	14,875			19,052
Perch		215				215
Rock Bass		7,400	9,780			17,180
Rockfish		14,108				14,108
Sardine		90				90
Sea-bass, Black		44,812	99,714			144,526
Sea-bass, Totuava	588,454					588,454
Sea-bass, White		133,341	10,481			143,822
Shark		995	1,189			2,184
Sheepshead		3,911	207			4,118
Smelt		1,319				1,319
Swordfish, Broadbill		4,645				4,645
Tuna, Albacore					234,731	234,731
Tuna, Bluefin		2,840	670			3,510
Tuna, Bonito	170	641,835	190,211			832,216
Tuna, Oriental					104,162	104,162
Tuna, Skipjack		7,786,659	3,700,686	7,336	34,166	11,528,847
Tuna, Yellowfin		2,667,455	6,649,293	7,667,534	87,031	17,071,313
Whitefish		15,796	711			16,507
Yellowtail		892,998	85,647			978,645
Miscellaneous fish			707			707
Crustacean:						
Lobster, Spiny		305,657				305,657
Shrimp	2,090					2,090
Total pounds	594,997	12,796,929	11,111,017	7,674,870	460,090	32,637,903

* These importations are included in tables of landings. They include fish caught by California boats in foreign waters as well as frozen fish imported for canning in California plants.

CALIFORNIA FRESH FISH LANDINGS* FOR OCTOBER, NOVEMBER AND DECEMBER, 1937

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	Region 10, Del Norte	Region 20, Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds
Anchovy.....				1,800	10,000		64,835		76,635
Barracuda.....						35,786	377,670	224,496	637,952
Cabezone.....				515	826	78			1,419
Cabrilla.....							15,113	1,874	16,987
Carp.....			12,137						12,137
Carfish.....			154,188						154,188
Corbina, Mexican.							738		738
Cultus, Pacific.		51,503		108,465	58,361	471	470		225,374
Eel.....	6,104						123		192
Flounder, Starry		15		36,704	2,658		788		39,377
Flying Fish.....							3,984		793
Grouper.....							3,678	306	3,984
Hake.....				21,020			15		21,035
Halibut, California.				3,193	4,195	114,280		58,134	207,208
Halibut, Northern.		5,360							5,360
Hardhead.....			28,985						28,985
Herring, Pacific.				78,030	47,302		97,921	4,107	148,713
Kingfish.....				311	2,029	65		114	3,215
Mackerel, Horse.				7,476	331,724	17,061	1,024,595		1,936,024
Mackerel, Pacific.							18,674,721	454,644	19,453,636
Mackerel, Spanish.							14,575	4,177	19,652
Mullet.....							257		257
Perch.....		15		19,427	864	739	34,198	215	55,458
Pike.....			85						85
Pompano, California.							51		51
Rock Bass.....						3,877	27,277	27,769	57,923
Rockfish.....	4,832	23,914		244,313	730,993	62,729	120,149	34,588	1,221,515
Sablefish.....		78,543		2,550	16		24,583		105,692
Salmon.....			307						307
Sand Dab.....				132,641	2,185		1,678		136,504
Sardine.....			33,783,700	141,559,352	159,278,906		107,943,987	214,355	442,785,300
Sculpin.....									
Sea-bass, Black.						36		3,910	28,733
Sea-bass, Short-fin.						6,746		45,522	152,463
Sea-bass, Totuaya.								10	10
Sea-bass, White.							588,454		588,454
Shark.....		873	7,288	185,464	4,947	38,781	17,433	143,773	222,747
					69,255	26,065		12,192	318,600

Sheepshead					2,479	24,421	5,733	32,633
Skate					10,825	1,386		139,232
Snelt	2,867				1,957	56,594	1,810	129,333
Sole					38,358	283		2,015,740
Split-tail		1,311						1,311
Sucker		3,808						3,808
Swordfish, Broadbill					7,042	77,085	60,585	144,712
Tuna, Albacore						904,198		1,025,717
Tuna, Bluefin	258				120	171,987	2,840	174,947
Tuna, Bonito					3,896	677,910	712,525	1,394,369
Tuna, Oriental						104,162		104,162
Tuna, Skipjack					19	1,818,461	9,871,266	11,689,746
Tuna, Yellowfin					195	3,422,601	13,649,656	17,072,452
Turbot					36			24,142
Whitefish					11,052	6,491	18,895	36,438
Yellowtail						93,903	888,110	982,013
Miscellaneous Fish	6,820				1,117	3,914		49,438
Crustacean:								
Crab								798,264
Crab, Rock	17,564					162		162
Loyster, Spiny					78,850	153,752	378,948	611,550
Prawn								1,576
Shrimp						2,090		163,954
Mollusk:								
Abalone								595,769
Clam, Cockle						1,582		6,065
Clam, Gaper	1,056					5,969		1,482
Clam, Pismo								55,713
Clam, Soft-shell					7,428			23,985
Clam, Washington					48,265			7,143
Octopus	6,678							810
Oyster, Eastern	100					91		121,122
Oyster, Japanese	6,657							279,526
Oyster, Native								1,798
Squid								283,174
Total pounds	11,484	202,229	33,991,759	145,953,409	161,258,351	137,666,050	26,820,551	506,767,763

* Importations of fresh fish from foreign countries included. See foreign importation tables.

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BUREAU OF HYDRAULICS

JOHN SPENCER, Chief.....	San Francisco
Clarence Elliger, Assistant Hydraulic Engineer.....	San Francisco
Byron Wittorff, Assistant.....	San Francisco

BUREAU OF LICENSES

H. R. DUNBAR, Chief.....	Sacramento
J. J. Shannon, License Agent.....	Sacramento
L. O'Leary, License Agent.....	San Francisco
R. Nickerson, License Agent.....	Los Angeles

BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol.....	San Francisco
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CENTRAL DISTRICT (Headquarters, Sacramento)

S. H. Lyons, Inspector in Charge.....	Sacramento
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Northern Division

Jos. H. Sanders, Captain in Charge.....	Sacramento
Don Chipman, Warden, Flying Squad.....	Redding
Eugene Durney, Assistant Warden, Flying Squad.....	Sacramento
A. H. Willard, Captain.....	Nevada City
A. A. Jordan, Captain.....	Redding
Chas. Sibeck, Warden, Launch "Rainbow".....	Sacramento
Otis Wright, Assistant Warden, Launch "Rainbow".....	Sacramento
J. E. Hughes, Warden, Modoc County.....	Alturas
Brice Hammack, Warden, Siskiyou County.....	Yreka
Fred R. Starr, Warden, Siskiyou County.....	Dorris
C. L. Gourley, Warden, Trinity County.....	Weaverville
Earl Caldwell, Warden, Shasta County.....	Burney
Chas. Love, Warden, Shasta County.....	Redding
C. O. Fisher, Warden, Lassen County.....	Susanville
W. C. Blewett, Warden, Plumas County.....	Quincy
R. W. Anderson, Warden, Tehama County.....	Red Bluff
E. C. Vail, Warden, Glenn County.....	Willows
L. E. Mercer, Warden, Butte County.....	Chico
A. Granstrom, Warden, Sierra County.....	Downsville
Earl Hiscox, Warden, Nevada County.....	Nevada City
R. A. Tinnin, Warden, Yuba County.....	Browns Valley
L. W. Dinsdale, Warden, Sutter County.....	Yuba City
Taylor London, Warden, Colusa County.....	Colusa
R. L. Sinkey, Warden, Yolo County.....	Woodland
W. J. Black, Warden, Solano County.....	Suisun
H. S. Vary, Warden, Sacramento County.....	Sacramento
Nelson Poole, Warden, Placer County.....	Auburn
Albert Sears, Warden, El Dorado County.....	Placerville

Southern Division

S. R. Gilloon, Captain in Charge.....	Fresno
Gilbert T. Davis, Warden, Flying Squad.....	Fresno
John O'Connell, Captain.....	Stockton
E. O. Wraith, Captain.....	Bakersfield
Wm. Hoppe, Warden, San Joaquin County.....	Lodi
R. J. Little, Warden, Amador County.....	Jackson
J. W. Thornburg, Warden, Calaveras County.....	Angels Camp
F. F. Johnston, Warden, Tuolumne County.....	Sonora
Geo. Magladry, Warden, Stanislaus County.....	Modesto
M. S. Clark, Warden, Merced County.....	Merced
Ray Ellis, Warden, Kings County.....	Hanford
Clarence Brown, Warden, Mariposa County.....	Mariposa
H. E. Black, Warden, Madera County.....	Madera
Paul Kehrer, Warden, Fresno County.....	Fresno
F. A. Bullard, Warden, Fresno County.....	Reedley
R. J. Bullard, Warden, Tulare County.....	Porterville
W. I. Long, Warden, Tulare County.....	Visalia
C. S. Donham, Warden, Merced County.....	Gustine
Lester Arnold, Warden, Kern County.....	Bakersfield
Roswell Welch, Warden, Kern County.....	Kernville

COAST DISTRICT (Headquarters, San Francisco)

K. P. Allred, Inspector in Charge.....	San Francisco
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Northern Division

W. J. Harp, Captain in Charge	Ukiah
R. E. Tutt, Warden, Flying Squad	Willits
R. Remley, Warden, Flying Squad	Willits
J. D. Dondero, Captain	Eureka
Henry Lencioni, Captain	Santa Rosa
John Hurley, Warden, Humboldt County	Eureka
W. F. Kaliher, Warden, Humboldt County	Fortuna
Ovid Holmes, Warden, Mendocino County	Fort Bragg
Leo Mitchell, Warden, Mendocino County	Point Arena
E. J. Johnson, Warden, Lake County	Lakeport
J. H. Groves, Warden, Sonoma County	Cloverdale
Victor Von Arx, Warden, Sonoma County	Santa Rosa
Bert Laws, Warden, Sonoma County	Petaluma
J. W. Harbuck, Warden, Napa County	Napa
R. J. Yates, Warden, Marin County	San Rafael
Scott Feland, Warden, Del Norte County	Crescent City

Southern Division

Wm. Lippincott, Captain in Charge	San Francisco
L. R. Garrett, Warden, Flying Squad	Salinas
Owen Mello, Warden, Flying Squad	Salinas
O. P. Brownlow, Captain	Alameda
Ed Clements, Warden, Contra Costa County	Salinas
C. L. Bundock, Warden, Alameda County	Martinez
C. E. Holladay, Warden, Santa Clara County	Oakland
Lee C. Shea, Warden, San Francisco County	San Jose
C. R. Peek, Warden, San Mateo County	San Francisco
F. J. McDermott, Warden, Santa Cruz County	San Mateo
J. P. Vissiere, Warden, San Benito County	Santa Cruz
F. H. Post, Warden, Monterey County	San Juan Bautista
Orben Philbrick, Warden, Monterey County	Salinas
F. W. Hecker, Warden, San Luis Obispo County	King City
	San Luis Obispo

Marine Fisheries Detail (Coast District)

Ralph Classic, Captain	Monterey
L. J. Weseth, Master, M. V. "Albacore"	San Francisco
Kenneth Hooker, Warden, Cruiser "Quinnat III"	San Francisco
W. H. Sholes, Assistant Warden, Cruiser "Quinnat III"	San Francisco
Leslie E. Lahr, Warden	Eureka
G. R. Smalley, Warden	Richmond
Ralph Miller, Warden	San Francisco
Charles Holzhouser, Warden	Watsonville
Charles Mayfield, Warden	Monterey

SOUTHERN DISTRICT (Headquarters, Los Angeles)

C. S. Bauder, Inspector in Charge	Los Angeles
E. H. Ober, Captain Special Duty	Los Angeles

Western Division

L. F. Chappell, Captain in Charge	Los Angeles
Theo. Jolley, Warden, Flying Squad	Los Angeles
Walter Shannon, Warden, Flying Squad	Los Angeles
L. T. Ward, Captain	Escondido
Earl Macklin, Captain	Santa Barbara
A. R. Ainsworth, Warden, Santa Barbara County	Santa Maria
R. E. Bedwell, Warden, Santa Barbara County	Santa Barbara
G. N. Johnson, Warden, Ventura County	Ventura
Fred Albrecht, Warden, Los Angeles County	Los Angeles
James Loundagin, Warden, Imperial County	Brawley
W. L. Hare, Warden, Los Angeles County	San Fernando
Walter Emerick, Warden, Orange County	Santa Ana
E. H. Gilden, Warden, San Diego County	San Diego

Eastern Division

H. C. Jackson, Captain in Charge	San Bernardino
Ray Diamond, Warden, Flying Squad	San Bernardino
A. L. Stager, Warden, Flying Squad	San Bernardino
_____, Captain	Elishop
_____, Captain	Banning
Al Crocker, Warden, Mono County	Bridgeport
C. J. Walters, Warden, Inyo County	Independence
E. L. Walker, Warden, Inyo County	Bishop
W. C. Malone, Warden, San Bernardino County	San Bernardino
W. S. Talbott, Warden, San Bernardino County	Pine Knot
J. H. Gyger, Warden, Riverside County	Ferris
R. C. O'Conner, Warden, Riverside County	Banning

Marine Fisheries Detail (Southern District)

C. H. Groat, Captain in Charge	Terminal Island
Walter Engelke, Master, M. V. "Bluefin"	Terminal Island
E. R. Hyde, Warden, Cruiser "Yellowtail"	Balboa
Niles Millen, Assistant Warden, Cruiser "Yellowtail"	Balboa
Robt. Cowell, Warden, Cruiser "Marlin"	San Diego
W. E. Scrimsher, Assistant Warden, Cruiser "Marlin"	San Diego
Carini Savage, Warden, Cruiser "Tuna"	Avalon
Karl Lund, Assistant Warden, Cruiser "Tuna"	Avalon
Howard V. Shebley, Warden, Cruiser "Bonito"	Santa Barbara
Assistant Warden, Cruiser "Bonito"	Santa Barbara
John Spicer, Warden, Cruiser "Broadbill"	Santa Monica
Donald Glass, Warden, Cruiser "Broadbill"	Santa Monica
N. C. Kunkel, Warden	Terminal Island
E. A. Chan, Warden	Terminal Island
L. G. Van Vorhis, Warden	Terminal Island
Erol Greenleaf, Warden	Terminal Island
Tate F. Miller, Warden	Terminal Island
T. J. Smith, Warden	San Diego
Lester Golden, Warden	Arroyo Grande

POLLUTION DETAIL

Paul Shaw, Chemist in Charge	San Francisco
C. L. Towers, Warden	Los Angeles
Wm. La Marr, Warden	Oakland
Don Davison, Warden	Sacramento
E. A. Johnson, Assistant Warden	San Francisco
R. Schoen, Assistant Warden	Los Angeles

CALIFORNIA JUNIOR GAME PATROL

M. F. Joy, Warden, Superintendent Junior Game Patrol	San Francisco
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MARINE PATROL

Motor Vessel "Bluefin,"	Terminal Island
Motor Vessel "Albacore,"	Monterey
Cruiser "Yellowtail,"	Newport Harbor
Cruiser "Broadbill,"	Santa Monica
Cruiser "Quinnat III,"	San Francisco
Cruiser "Bonito,"	Santa Barbara
Cruiser "Marlin,"	San Diego
Cruiser "Tuna,"	Avalon
Launch "Rainbow,"	Sacramento
Launch "Shrapnel,"	Lakeport
Launch "Silverside,"	Eureka
Launch "Sturgeon,"	Martinez